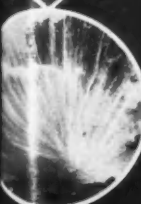
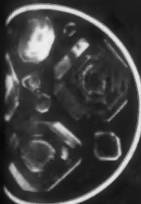




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CHEMISTRY



DECEMBER
1944

Newest Nobel Prize Researches:

Vitamin K Prevents Bleeding Death.....	2
Electrical Pictures of Nerve Action.....	5
Secrets of Atom's Heart.....	7
Isotopes Indicate Chemical Properties.....	9
Air Sterilization Checks Infection.....	11
Lignin, Chemical Cinderella.....	13
Jellied Gasoline New Incendiary.....	17
Wanted: Engine Using 100-Octane.....	19
Odorless Household Fly Spray.....	21
Chemical Things to Do:	
Solid Alcohol for Tin Can Stove.....	24
Chem Quiz: Do They Mean What They Say?...	25
Chemical Patents of the Month.....	26
Classics of Chemistry:	
The Three Hydrogens.....	32
Who's Who in Hydrogen.....	39
New Germ-Killing Soap Developed.....	40
Chemicals by Calculation.....	41
Progress Reports on Penicillin.....	43
Science Talent Search Essay:	
Experiment in Chemical Gardening.....	46
Introduction to Chemistry:	
States of Matter.....	49
Chemical Magic:	
Sodium Silicate Gardens.....	58
Editorial:	
Is It Good or Bad? .. Inside Front Cover	

25¢

Is It Good or Bad?

➤ AN ATTITUDE of mind which crops up frequently in discussions of the post-war world tries to blame all the world's troubles on science. The poor, dear human race, we gather from these commentators, would always be kind and gentle if it were not continuously led astray by such evil companions as, for instance, chemistry.

Let's get this argument into concrete terms, and see how it works out. Let's take lead. Is lead good or bad for the human race? Lead comes from galena, PbS, an exceedingly heavy kind of rock with sharp corners. It would make an excellent weapon, and doubtless has frequently been so used. That's bad. After it has been smelted, lead makes bullets. That's worse. Lead salts are poisonous, too.

Of course, the poisonous salts can be used as insecticides. That helps our side. And lead paint protects our property. In other compounds, lead gives the sparkle to cut glass, and the kick to gasoline comes from tetra-ethyl lead. Lead and sulfuric acid make storage batteries.

The weight of lead makes it useful for fishing-line sinkers and plumb-line bobs. Its workability made it useful for leading windows and flashing roofs in medieval castles and cathedrals. In modern building, it named the plumbing.

Lead is even responsible for the type which printed this magazine. And there is its place in the radio-active series. There all roads lead to lead.

Is lead good or *bad*? Should it be abolished?—H. M. D.

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NEWEST NOBELISTS

Henrik Dam

Herbert S. Gasser

Edward A. Doisy

Isidor I. Rabi

Joseph Erlanger

Otto Stern

Georg von Hevesy



Thousands are saved from bleeding death.

Electrical pictures of nerve action are brought closer.

Secrets of the atom's heart are discovered.

Isotopes aid in the study of chemical properties.

Such are the consequences of the scientific researches signalized in the seven Nobel awards just announced. CHEMISTRY is proud to present reports of these researches and interpretations of these important advances as told by the Nobelists in their own words.



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The Nobel Prizes In Medicine

► THOUSANDS of men, women and newborn babies have been saved from bleeding to death and electrical pictures of human thought and pain are coming closer to practical reality as a result of the fundamental discoveries for which the Nobel Prizes in medicine for 1943 and 1944 were awarded.

Since 1938 patients with obstructive jaundice and with certain other conditions in which a dangerous bleeding tendency exists have been treated with vitamin K, the anti-bleeding vitamin. It gets its name, K, because the German and Scandinavian word for coagulation is spelled Koagulation, and this vitamin was discovered by a Danish scientist, Dr. Henrik Dam, now at Strong Memorial Hospital, Rochester, New York. For this discovery Dr. Dam shares the 1943 Nobel Prize in medicine with Dr. Edward A. Doisy, St. Louis University Medical School.

On May 3 of this year Dr. Doisy and associates were granted patent rights on pure, synthetic vitamin K, culminating many years of research on the chemical structure and method of synthesizing the vitamin. Ten years before, in June of 1934, the world first learned of the existence of this vitamin.

"Possible existence of another hitherto unknown vitamin, with ability to prevent hemorrhage, is seen in experiments reported by Dr. Henrik Dam, of the Biochemical Institute, Copenhagen," Science Service reported on June 26, 1934.

"Chicks fed an experimental diet developed a disease very much like scurvy, the chief features being exten-

sive internal hemorrhages," Science Service's account of Dr. Dam's report to the British scientific journal, *Nature*, continued.

"Large doses of anti-scurvy vitamin C in the form of lemon juice and ascorbic acid did not have any effect on the disease, but a diet consisting entirely of cereals or seeds plus salt prevented the occurrence of the hemorrhages.

"The cause of the disease must therefore be a deficiency in an anti-hemorrhagic factor different from vitamin C and occurring in seeds and cereals," was Dr. Dam's conclusion.

When this vitamin was first used to treat human patients it had to be given in what many of them must have thought was food fit only for chicks, dried alfalfa or dried fish meal. Thanks to the work of Dr. Doisy and a host of other biochemists, patients today can be given the vitamin as a synthetic preparation in a pill or by hypodermic injection.

Less dramatic and far harder for the layman to understand is the fundamental research on nerves for which Dr. Joseph Erlanger, of Washington University School of Medicine, and Dr. Herbert S. Gasser, director of the Rockefeller Institute for Medical Research, share the 1944 Nobel Prize in medicine. Yet modern methods of learning about the electrical changes accompanying nerve activity, including the familiar brain waves which scientists believe will some day be developed to the point of telling what a person is thinking about whether he wants to tell them or not, were started



Dr. Henrik Dam

by Dr. Erlanger and Dr. Gasser. The history of these developments is briefly traced by Dr. R. W. Gerard, of the University of Chicago, somewhat as follows:

"One hundred years ago changes in potential in active nerves were discovered with the aid of the then newly developed galvanometers. Another half century saw the invention of the string galvanometer, by the physiologist, Einthoven, to permit the measurement of the rapid flicks made by responding tissues which opened the era of electrocardiography. In the early twenties, amplifier tubes were used with the string galvanometers and shortly after with the Braun tube by physiologists



Dr. Edward Doisy

at Harvard and Washington Universities.

"The latter, especially Erlanger and Gasser, were thus able, for the first time, to disentangle the impulses in one nerve fiber from those in others and to show that several types of fibers existed with very different conduction rates."

As a result of this work we now know, says Prof. Edgar Douglas Adrian, of Cambridge University and himself a Nobel in medicine, "that the sensory fibers can be ranged in decreasing order of size, velocity of conduction and excitability to electric stimuli and that pain reactions are mainly due to the smaller fibers."

Past and Future of Vitamin K

by DR. HENRIK DAM

➤ GLADLY surprised at being recipient of a Nobel prize in medicine, my thoughts turn to work still to be done on vitamin K as well as to the days of its discovery.

Future research must clear up the manner in which vitamin K acts to promote the formation of prothrombin, one of the blood chemicals essential for normal clotting of blood when shed. It is only known that the process takes place in the liver.

It also remains to be found out what role vitamin K plays in the green plants and in bacteria.

Vitamin K, first found in Copenhagen in experiments with chicks, is necessary for blood clotting. Without vitamin K fatal bleeding occurs even from minor wounds.

Vitamin K is fat-soluble and occurs in various foods, especially in green vegetables. It also occurs in putrefaction bacteria.

Vitamin K prevents bleeding diseases which are due to lack of prothrombin, a protein-like substance occurring in the blood of normal persons. Vitamin K is not related to the hereditary bleeder's disease, hemophilia. Vitamin K deficiency occurs in cases of so-called

obstructive jaundice caused by gall stones or tumors which obstruct the flow of bile into the intestine, bile being necessary for the absorption of vitamin K from foodstuffs through the intestinal wall into the blood stream.

Death from continuous bleeding was formerly a very serious problem in surgical operations on such patients, but this risk is now avoided by suitable administration of vitamin K.

Newborn babies are usually more or less vitamin K deficient because the vitamin does not readily pass over from mother to fetus. Danger of bleeding exists in many newborn in the first few days after birth. This danger is prevented and the death rate among the newborn reduced by administration of vitamin K to the baby immediately after birth.

Certain forms of sulfa drug treatment will kill the bacteria in the patient's intestine thereby excluding an important source of vitamin K. Vitamin K therapy is advisable in such cases.

Uncontrolled excessive use of mineral oil may interfere with the proper absorption of vitamin K as well as of other vitamins.

Not since 1939 have the Nobel Prizes been awarded until this year. They were established in 1896 by the will of Alfred Bernhard Nobel, inventor of dynamite and other explosives. The first Nobel Prizes were awarded in 1901. Prizes in the fields of physics and chemistry are awarded by the Swedish Academy of Sciences, in Stockholm. The prize in medicine is awarded by the Caroline Medical Institute, also in Stockholm.

Chemical Development of Vitamin K

by Dr. EDWARD A. DOISY

► DURING the decade following Dr. Dam's discovery of vitamin K, the combined efforts of several groups of investigators have solved many of the important problems connected with vitamin K. Sources of the vitamin were discovered and in my laboratory methods of extraction and purification were devised. A satisfactory bioassay method was developed, and the isolation of vitamin K₁ (from alfalfa) and K₂ (from putrefied fish meal) was effected. The structures of K₁ and K₂ were elucidated and the structure of K₁ verified by synthesis and of K₂ by degradation studies. In addition, simple water-soluble compounds with antihemorrhagic properties were prepared for clinical use.

Many investigators had previously attempted to ascertain the cause of the impaired coagulation of blood in obstructive jaundice but it was not until

1935 that Dr. A. J. Quick and his associates devised a satisfactory method for the determination of prothrombin and showed that in obstructive jaundice the prothrombin concentration may be markedly reduced. The delayed coagulation in obstructive jaundice as well as in vitamin K deficient chicks can be corrected by the administration of vitamin K and bile or of the simple-water soluble compounds with antihemorrhagic properties.

In certain diarrheal diseases, such as ulcerative colitis, sprue and celiac disease which may cause hypoprothrombinemia, the intravenous therapy of vitamin K is effective. Another important therapeutic use of vitamin K is to correct the hemorrhagic disease of the newborn. The treatment is extensively and effectively used in the mother prenatally or in the infant after birth.

Electrical Messages From Nerves

by Dr. HERBERT S. GASSER

► THE WORK for which the 1944 Nobel prize in medicine was awarded to Dr. Joseph Erlanger, of Washington University, St. Louis, and myself is the direct outgrowth of the advancements of modern physics.

One of the signs of activity in the nervous system is a change in the electrical potential accompanying the events and this sign is the only one that tells when the events take place. These changes are so small that formerly they were difficult to detect and

at the same time the inertia of the recording instruments distorted their time course.

After the advent of the vacuum tube amplifier and the cathode ray oscillograph it was possible to develop a technique that surmounted both difficulties and then many older observations could be clarified and new ones brought to light.

The first developments were in relation to the peripheral nerve. It was possible to reveal differences in the



Dr. Herbert Gasser



Dr. Joseph Erlanger

individual fibers that make up a nerve, differences in the velocity with which impulses are carried related to the size of the axons and differences related to the kind of fiber, for it has turned out that fibers can be divided on criteria other than velocity into three classes.

To a limited extent the several groups of fibers could be related to the physiological significance of the messages they carry. The events in the course of a single impulse in a fiber were determined with accuracy as to time and correlated with states of the nerve.

Certain events correlate with the

momentary excitability of the fiber and this correlation forms a useful link in the chain leading up to an analytical study of the central nervous system. Some of the simplest neuron chains in the latter have been examined. But the subject is still in its infancy.

There are alluring prospects ahead with respect to the unravelling of how the central nervous system works. Needless to say, the foregoing summary contains allusions to contributions for which neurophysiology is indebted to the work of others than ourselves.



Dr. Otto Stern



Dr. Isidor I. Rabi

The Nobel Prizes In Physics

►DISCOVERING secrets of the atom's heart has won Nobel prizes for two physicists now in America Dr. Isidor I. Rabi of Columbia University received the 1944 Nobel award in physics for discovering radiations, emitted by atoms, that are pitched lower than any hitherto observed and devising his magnetic resonance method for measuring them. The 1943 prize in physics was given to Dr. Otto Stern of Carnegie Institute of Technology for investigating the structure of the atom by means of the "molecular beam" method.

Dr. Rabi found that atoms act like little radio transmitters broadcasting

on ultra-short waves. Their radiations are pitched lower than any previously recorded, but he was successful in devising a method of measuring them.

Dr. Rabi's work opened a way of measuring such subtle properties of atoms and molecules as the magnetism of their component parts, a hundred times more accurately than was possible by any available instrument. Of special significance is his conclusion that "there are no forces between the nucleus and the electrons because of their spins, other than those arising from the fact that the nucleus as well as the electron, is a magnet."

Professor of physics at Columbia University, Dr. Rabi is one of the most distinguished of the younger American physicists. Although he has spent almost his entire life in America, he was born in Austria in 1898 and brought to the United States in infancy.

Huge batteries salvaged from obsolete Navy submarines were used by Dr. Rabi and his associates at Columbia University in scientific experiments testing theories concerning the "spin" of electrons in the atom.

"In experiments under the direction of Prof. I. I. Rabi of Columbia's physics department," Science Service told its readers in December, 1935, "the giant batteries are connected in parallel and yield currents of hundreds of amperes. The intense magnetic field generated when these large currents are passed through helical coils are used to deflect charged ions. The study leads to new knowledge of the clockwise or counter clockwise spin of the electrons in the atoms which is intimately bound up with theory concerning magnetism."

Dr. Rabi's eminence in the study of radio frequency spectra of atoms and molecules won for him in 1940 the coveted \$1000 prize from the American Association for the Advancement of Science. He has won various other honors and was one of the outstanding American men of science invited

to attend the First National Congress on Physics in Mexico in May, 1943.

Dr. Stern investigated the structure of the atom by means of the "molecular beam" method which he and his collaborators at the Universities of Frankfort and Hamburg developed. Leaving Germany because of Nazi oppression, he continued his research at the Carnegie Institute of Technology where a \$25,000 grant from the Buhl Foundation in 1934 established a laboratory for him.

In the molecular beam method of physical experimentations, a gas from the element under study is passed through a fine hole into a chamber where a high vacuum is constantly maintained. Due to the high vacuum no collisions between the molecules occur and each molecule travels in a straight line. By a series of fine slits the direction of the molecules is controlled and a fine beam is cut out. This is the "molecular beam."

By directing the beam through the region of a magnetic field some of the atoms are deflected from the straight course, and a measurement of the deflection has enabled the physicist to calculate the magnetic moment of the atom—the magnetic force required to deflect them from a straight path.

By applying these studies and also those they have made in wave properties of matter, Prof. Stern and his collaborators have discovered many facts about the structure of the atom.

Powerful Nuclear Forces

by DR. ISIDOR I. RABI

➤ JUST as a century ago we were studying electrical and magnetic forces which culminated in great electrical and electronic industries, but

could not foretell that fact with certainty, now these immensely more powerful nuclear forces may be turned to the advantage of mankind.

My work was directed toward investigating the magnetic and electric properties of the atomic nucleus. The purpose was to gain further knowledge of the nature of the forces that hold the nucleus together and contribute to atomic energy. In the course of these investigations my colleagues and I developed the "molecular beam magnetic resonance methods" which employed the effect of radio waves on beams of atoms and molecules. This method was a million times more sen-

sitive than anything previously known.

Chief results of this work were the very precise measurements of the amount of spin and magnetism of a number of atomic nuclei, including the proton and the deuteron (the nucleus of heavy hydrogen). In addition it was discovered that the deuteron is shaped like a football spinning on its long axis. This fact has important consequences concerning the properties of nuclear forces.

Magnetic Moment of Proton

by DR. OTTO STERN

► FINDING that the magnetic moment of the proton was two and one-half times the value expected from the theory is fundamentally important because of the character of the proton as an elementary particle.

The molecular-ray method is much more sensitive than any other known methods for the determination of magnetic moments of atoms or molecules.

The method of molecular rays consists in preparing a stream of molecules by means of a system of fine slits. All molecules travel in the same direction in a highly evacuated apparatus.

Experiments with these molecular rays contribute to the solution of fundamental questions in atomic physics. Three examples may be mentioned: direct experimental proof for the space quantization of atoms by splitting a molecular ray of silver atoms in two beams in a magnetic field; experimental proof of de Broglie's theory that moving particles show wave properties by diffracting a molecular ray of helium or hydrogen molecules at a crystal lattice, and measurement of the magnetic moment of the proton by magnetic deflection of a beam of hydrogen molecules.

The Nobel Prize In Chemistry

► A DESIRE to engage in intensive studies relative to the use of X-rays on cancer, using the award coming to him as a Nobel prize winner, was expressed, it is reported, by Prof. Georg von Hevesy upon receipt of the notification. This 59-year-old professor of the Danish Institute of Theoretical Physics, Copenhagen, since 1943 a war

refugee living near Stockholm, received the 1943 chemistry award for his work in the use of isotopes as indicators in studying chemical properties.

Prof. Hevesy is well known among scientists in America. A course of lectures, given by him at Cornell University as a George Fisher Baker non-

resident lecturer in chemistry, was published in this country in 1932 under the title *Chemical Analysis by X-rays and Its Application*. His *Manual of Radioactivity* is also well known here, as are his other publications and his articles which have appeared from time to time in scientific publications. His work on the properties of the chemical element, Hafnium, is outstanding.

Among notable studies of Prof. Hevesy was one relative to how the muscle substance, known as creatine phosphoric acid, breaks down during muscular exercises, and how it is rebuilt or rejuvenated in the resting muscle. In this study he used atoms of sodium phosphate labelled by making them artificially radioactive so that no matter where they might be their presence would be detected by the radiations they produced.

Some of the labelled sodium phosphate was injected in frogs, and then, at various time intervals, creatine phosphoric acid was extracted from the muscle. The replacement of the phosphorus atoms could thus be traced.

In this study he followed methods previously used by him when he determined that the average time a water molecule stays in the body is about 13 days. In this investigation he used heavy hydrogen atoms in heavy water to detect the process of elimination. Heavy water is the combination of oxygen and the isotope of hydrogen known as deuterium. The molecules of this heavy water acted as tracers in studying how the body eliminates water by respiration and otherwise.

Heavy water was found by scientists to slow down the life processes in mice and other animals and was thought dangerous for human beings. However, Prof. Hevesy, while a professor at Freiburg, Germany, took very small quantities, not to test the possible poisonousness, but to use the double-weight hydrogen atoms as tracers in order to discover how long water remains in the human body. The water he drank contained 0.46% of heavy water. No harmful effects were reported.

The 1944 chemical prize will probably not be awarded until next year.

New Nicotine Salts for Insect War

► MUNITIONS FOR front-line fighting in man's endless defensive war against insects are supplied in the form of a series of new double salts of nicotine, prepared by Claude R. Smith of Philadelphia, chemist at the Northern Regional Research Laboratory of the U. S. Department of Agriculture. Rights in U. S. patent 2,356,185 on the new insecticides are assigned royalty-free to the government.

Simpler nicotine compounds, like

nicotine sulfate, have long been used for insect-fighting purposes. They have the disadvantage, however, of not remaining effective very long when dusted on plants. Efforts to "fix" nicotine, as by mixing it with bentonite, so that it will spread its poisonous action out over a longer period of time, have often resulted in locking up the nicotine too tightly. The metallic double salts which Mr. Smith has developed in his researches seem to be a happy medium.

Chemical Vapor or Ultraviolet Light Used in Sleeping Rooms

Air Sterilization Checks Infection

by JANE STAFFORD

Two significant demonstrations preventing disease have resulted from medical war research.

Glycol Vapor Checked Mumps

► CHECKING the spread of colds and other air-borne diseases by sterilizing the air of living quarters with an invisible, odorless, non-irritating, inexpensive vapor of triethylene glycol is now more than a hope based on laboratory experiments. It has become a practical method of disease-fighting that passed rigorous tests in a military camp as reported by Dr. Edward Bigg, Prof. B. H. Jennings and F. C. W. Olson, of Northwestern University.

Specifically, it reduced the total bacterial air contamination; practically eliminated hemolytic streptococci from the air of glycol-treated dormitories; definitely reduced cases of air-borne infections, such as colds, tonsillitis, pneumonia, measles and acute sinusitis; controlled a small epidemic of mumps; prevented the spread of hemolytic streptococci from the throat of one person to another.

The tests, done under contract between the Office of Scientific Research and Development and Northwestern University, were made in two two-story barracks each divided into eight dormitories. Each dormitory housed about 80 men in 40 double bunks about one and one-half feet apart. Four of the dormitories were used for the test

and four were kept as controls. These last did not get any of the glycol vapor treatment of the air.

The men mingled during the day in mess-halls, class-rooms, drill-halls, recreation rooms and so on, but as the greatest degree of air contamination and of cross infection is believed to occur in sleeping quarters, it was decided to treat only these for the test.

The test was divided into three periods, since every six weeks a new group of men replaced the previous group in the dormitories. Altogether there were 1,000 in the test group and 1,000 in the control group.

During the small mumps epidemic there were about the same number of cases developing in the control barracks as in the test barracks during the first three weeks, which is the incubation period of this disease. After that period there were only four more cases from the test barracks while 14 cases occurred in the control barracks that had no glycol vapor. The men who developed the disease during the first three weeks acquired the infection before coming under observation in the test.

For the other diseases, measles, colds, pneumonia and the like whose germs spread through the air, there was little difference between the control and test groups during the first three weeks of each test period. Combining the

figures for the first two test periods, there were a total of 126 hospital admissions from the control dormitories and 111 from the test quarters, a reduction of 12 per cent.

For the final 17 days of both periods, however, there were 53 from the control and 19 from the test, a reduction of 64 per cent in cases of illness.

Ultraviolet Reduces Illness

► **RESPIRATORY** illness, such as bad colds with fever, German measles, and the like, was reduced one fourth by ultraviolet irradiation of dormitories at the U.S. Naval Training Center, Sampson, N. Y., during the winter of 1943-1944.

Germ-killing ultraviolet light has previously been used to check the spread of disease in hospital wards and school rooms and to sterilize the air about the patient in operating rooms. This, however, was its first test in military barracks. The test was made by a six-man team of U.S. Navy disease fighters, Lieut. S. M. Wheeler, Lieut. Hollis S. Ingraham, Dr. Alexander Hollaender, Lieut. Comdr. Nicholas D. Lill, Lieut. Comdr. Jacob Gershon-Cohen and Capt. E. W. Brown.

The 25 per cent reduction in respiratory illness was achieved in those barracks equipped with high intensity sources of ultraviolet energy. Other barracks without the ultraviolet irradiation served as controls.

In the irradiated barracks, lamps

were hung from the ceilings of dormitories and were installed under every other bunk. These last had their ultraviolet rays directed downward to strike at germs on the floor and in the dust. Only sleeping quarters were irradiated. Drill halls, mess halls and the like were not.

The visible light from the powerful lamps was too low to interfere with sleeping and the men found it similar to bright moonlight. Practically none complained of any harmful effect on the eyes. The effect of the ultraviolet in checking disease was most marked in the early winter months when illness rates were at a generally high level throughout the camp. At this time reduction of illness in the irradiated barracks over the non-irradiated was over 35 per cent.

Illness due to streptococci, such as scarlet fever and strep sore throats, and healthy carriers of these germs were at a very low level in the camp and were not further reduced among men living in the irradiated barracks. Samples of the air showed only half as many germs of all kinds in the irradiated quarters as in the non-irradiated. Because the reduction of sickness rates was marked only during the first months of the test, the Navy scientists say the results "should be interpreted with caution." Further tests, planned for the coming winter, may tell the final story of how effective ultraviolet light can be in checking disease in barracks.

Indian cattle for American soldiers in India are slaughtered in accordance with Moslem custom; the native butchers dress in white, and as each animal is killed, a prayer is said; then American soldiers dress the carcass.

**Partner of Cellulose in Wood
Finding Use in Soils and Roads**

Lignin, Chemical Cinderella

by MARTHA MORROW

► LIGNIN, partner of cellulose in wood, may some day be the source of gasoline, dye stuffs and insecticides. Metals may be kept from rusting by a coating of lignin, and bridges and buildings made of odd pieces of wood bonded together by lignin.

Today lustrous ebony plastics and inexpensive building materials are being made from this natural substance, all too frequently regarded as mill waste. Lignin is already being used to improve soils and build roads. It is well adapted for electrical insulation equipment.

The future of lignin, the uninviting and often unwanted product left when cellulose is extracted from wood, depends on the skill, ingenuity and knowledge of chemists. Once we know more about lignin, a vast new field will open up, possibly as broad and varied as that of cellulose, one of the great fundamental materials of modern civilization.

Secret Sought

Chemists in secluded laboratories throughout the country are today seeking to discover the secret of this raw material. (See flask of lignin on page 15.) Some strive to make the streams purer by discovering a profitable use for this material which today is polluting them. Others seek more remunerative ways of employing sawdust and wood chips, millions of tons of which are wasted annually. Others,

desiring to keep our country green with trees, hope to develop new uses for wood products which would help make the business of growing trees economically more attractive.

If a use of lignin can be found which would raise the selling price only one cent a pound, it has been estimated that the cost of producing ethyl alcohol from wood waste in a plant now under construction in Oregon would be cut almost in half. If salvaging lignin from the waste liquors of pulp mills could be proved worthwhile, added profits would go to the paper industry for keeping the streams, formerly polluted with mill waste, more inviting to wild life and vacationists.

Lignin is found along with cellulose in most plants, in their leaves as well as in the wood itself. It may well be conceived as the cementing material that binds the cellulose fibers together in the wood structure. Without it wood would be limp and flexible.

Composition Known

Chemists know in general what lignin is composed of, but they don't yet know how it is put together. A typical wood lignin contains approximately 64 per cent of carbon, 5.6 per cent of hydrogen and 30.4 per cent of oxygen. It is not a carbohydrate because the atoms of hydrogen and oxygen are not in the proportion of two to one, which is a characteristic of the molecular structure of carbohydrates such as cellulose.

The atomic proportions in lignin are, roughly, carbon 46, hydrogen 48, and oxygen 15. Just how these are linked together is a question chemists today are trying to solve. After it is separated from wood, lignin is found chiefly in the form of dissolved lignin or insoluble lignin.

Dissolved lignin is a by-product left from paper pulp manufacture. Some of it comes from the sulfite cooking process and some comes from the alkaline cooking process, both of which are used in making the pulp from which paper is manufactured. Papers made by the first process are largely bond papers, book papers and writing papers. When such pulp is highly purified, it is a raw material from which rayon is made. Papers made by the alkaline-cooking process consist largely of kraft papers, most of which is used in wrapping and making containers.

Lignin solutions from sulfate mill wastes may be evaporated. Concentrated lignin of this type has been used rather extensively as a road binder to control dust. Lignin may be recovered from the wastes of the alkaline pulping process by a simple chemical treatment which causes it to become insoluble. In this form it is used chiefly as a bonding agent for plastics with a fiber base. There are possibilities of utilizing the ability of lignin to combine not only with fiber but with other proteins as well.

Insoluble lignin is derived chiefly as a residue from the wood sugar process. In the saccharification of wood, the cellulose is converted into sugars by hydrolysis and these sugars may be fermented to ethyl alcohol or used to produce feed yeasts, and thus make

protein feed for livestock. One ton of dry soft-woods, such as pine or fir, will yield approximately 1,100 pounds of sugars. As a by-product of this process, about 6000 pounds of lignin are produced which may be dried to a fine powder.

What to do with this highly complicated and potentially valuable material is engaging the attention of chemists in both public and private laboratories.

Since it contains about 64 per cent of carbon, lignin can be used as a fuel. It gives off as much heat upon burning as brown coal or lignite, and ignites in air at a temperature of 150 to 200 degrees Centigrade. But this is a relatively low-grade use of lignin.

One use of lignin now being explored is as a soil conditioner. Insoluble lignin, like other lignins, is related to humus in the soil, both humus and lignin having the same parents. One of its outstanding characteristics is that it is adsorbent. Because of this quality and its close relationship to humus, it will adsorb and hold chemicals valuable as plant nutrients, from simple inorganic substances to highly complicated proteins, and release them in a form readily utilized. Lignin isolated from sulfite liquor wastes may also be used after special treatment for this purpose.

May Be Purifier

This same quality of adsorption suggests the use of lignin as a purifier. From the air it will take acid, benzene and other gases. From solutions it will adsorb heavy metals, phenols and other chemicals often found in waste waters from chemical manufacturing plants. The insoluble form of lignin may be

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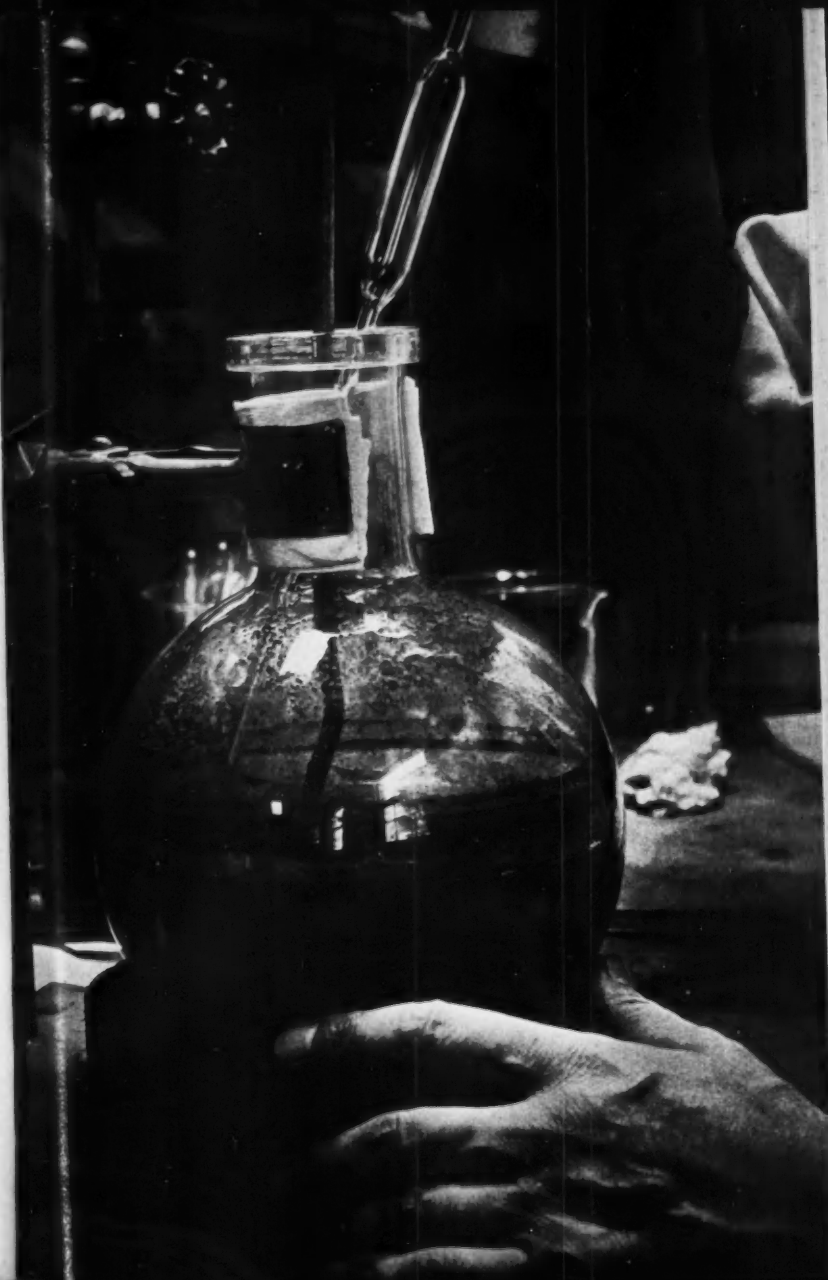
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valuable in the war against stream pollution.

Wood alone, untreated, is somewhat plastic at high temperatures and by the application of sufficient pressure small particles, such as sawdust and shavings, can be pressed into a compact mass. Such pressed material, however, is not strong and disintegrates rapidly when soaked in water.

Lignin, when separated from the other constituents of wood, is more plastic, although it tends to crack and crumble when used alone. Much attention is being given to the use of lignin as a plastic when combined with plasticizers and fibers.

If wood is partially hydrolyzed, only part of the cellulose is converted into sugar. This wood product, with a high lignin content, may be mixed with auxiliary plastics or plastic-forming constituents and be molded under heat and pressure. The resulting materials are highly resistant to water and acids, and have considerable flexural strength because of the cellulose fibers they contain.

A similar product is made by removing all the natural lignin from wood, leaving the cellulose. Then lignin of the type obtained from the alkaline-cooking process is introduced. It not only covers the fibers, but also impregnates the cellulose cells and pores. The product is hard, resistant to water and acid, a poor conductor of heat and electricity, and can be molded.

Sheets of laminating paper, made by running pulp with a high lignin content on a paper machine, after being treated with phenolic resins, are bonded together under heat and pressure. An extremely hard, board-like

material results which is quite different from the paper itself. This material, named papreg by the U. S. Forest Products Laboratory, which has done much research on lignin, is being used for electrical insulating panels. It can be sawed, turned and drilled just like hard wood. It is durable enough to form skids for planes landing on ice and snow.

The grain of the individual sheets of laminating paper may be made to run in the same direction. Or the grains may be crossed, in the same manner that grains of plywood veneers are crossed, thus creating desired strengths in various directions.

Another laminated product in which lignin has an important role consists of sheets of partially hydrolyzed wood, to which some phenolic resin has been added. These sheets may be run out something like paper and compressed together into panels. They are, in a sense, a sort of synthetic plywood, which may come to have wide uses as a cheap structural material.

By controlling the proportions of lignin and cellulose under special treatment, products entirely different from wood may be made which meet needs that wood, in its natural state, cannot fill.

If you would like to have samples of the dry lignin powder, plastic made from lignin and a little cellulose, and a sample showing how the individual sheets are laminated into a solid, hard board, you can secure the Lignin Unit of THINGS of science, a kit prepared by Science Service, by sending 50 cents to SCIENCE SERVICE, 1719 N Street, N.W., Washington 6, D. C., and asking for THINGS unit No. 47.

Raspberry or Orange Jelly for Flamethrowers and Fire Bombs

Jellied Gasoline New Incendiary

► JELLIED GASOLINE, food for flamethrowers and fire bombs, looks like raspberry or orange gelatin but is far more deadly. It is made to order at the battlefronts by stirring a secret white powder into ordinary motor fuel.

Developed through a co-operative research program under the direction of the War Department and the Office of Scientific Research and Development, the incendiary material has already proved a potent weapon against the enemy. The jellied gasoline and the two weapons that use it were developed as a result of the serious shortage of magnesium, the white metal formerly used for incendiaries. The new materials are as effective as the magnesium bomb, and can be produced in mass quantities with readily available materials.

Characteristics of jellied gasoline are that it maintains an intense flame over a period of 8 to 10 minutes and it sticks to its target, igniting any substance that will burn, such as wood or cloth, at temperatures as low as 40 degrees below zero Fahrenheit.

Buildings and machinery shattered by explosives are often rebuilt, but those razed by fire are frequently destroyed beyond repair and are therefore abandoned. For this reason Army Air Force bombers have increased the proportion of incendiaries carried on each operation until today some opera-

tions carry up to 50 per cent jellied gasoline oil bombs.

Flamethrowers spit streams of the jellied gasoline into enemy fortifications, such as pillboxes, and into moving tanks. The range of these powerful blowtorches is so long that operators can shoot flames from beyond the range of enemy small arms.

New Whip-Like Oil Bomb

A terrifying new six-pound oil bomb, the M69, using the jellied gasoline, is credited with creating a fire that all but destroyed the northwest section of the city of Changsha, China, now occupied by the Japanese, the first time it was put into use, last July.

Landing in the streets and on rooftops, the bomb spits chunks of flaming oil up to 25 yards in all directions. These flaming chunks of oil cling to the surface of whatever they strike, making them one of the most effective fire-starters developed in this war. The glow against the sky above Changsha was visible to Army Air Force pilots for 80 miles, and columns of black smoke could be seen rising to a height of more than half a mile.

The new fire bomb, developed by the Chemical Warfare Service, consists of a slender six-sided steel case 19 inches long and no bigger around than a baseball bat. The center portion of the cylinder holds a cheesecloth sock containing about three pounds of gasoline blended with a thickening com-

pound. This orange mixture burns at a temperature of about 3,000 degrees Fahrenheit. Each bomb holds enough of the jelly-like substance to make a flaming flapjack a quarter of an inch thick and a yard in diameter.

White cloth streamers, packed in the tail, act like parachutes to slow the descent of the bomb so that it will not smash to bits when it lands, and yet

leaving it with sufficient force to pierce roofs covered with tile, slate, wood, galvanized iron, or composition shingles.

In about five seconds after the bomb lands, a delayed action fuse spits out the cheesecloth sock from the tail of the bomb and ignites it. The bomb burns for 8 to 10 minutes. The bombs are dropped from planes in clusters of 38.

Human Body Manufactures Riboflavin

► RIBOFLAVIN, one of the B vitamins, is synthesized by bacteria in the human intestinal tract, an experiment conducted in Baltimore by Drs. Victor A. Najjar, George A. Johns, George C. Medairy, Gertrude Fleischmann and L. Emmett Holt, Jr., disclosed.

Their findings cast doubt on the high and universal requirement for riboflavin that has previously been accepted, they state in reporting the experiment to the Journal of the American Medical Association.

Twelve boys between ten and sixteen years old were the subjects of the experiment. They lived for 12 weeks on an experimental diet of purified vitamin-free foods. A vitamin mixture was given them separately, but it contained no riboflavin. The only riboflavin they got was a minute amount—between 70 and 90 micrograms daily—which occurred in casein that was supposed to be vitamin free.

Yet, despite this low intake of riboflavin, the body wastes were found to contain five to six times as much as

was taken in the food—a fact that could be explained only by the production of riboflavin by the intestinal bacteria. Giving them succinylsulfathiazole, which checks the production of thiamin by intestinal bacteria, had practically no effect on the production of riboflavin.

During the three months of the experiment, the boys remained in excellent health except for one who developed a Vincent's stomatitis during the second week. This cleared up, however, without the boy's taking any riboflavin.

It has been known previously that riboflavin is manufactured in the intestines of rats and ruminant animals, but it had not been previously demonstrated that it occurs also in humans, the investigators state.

Further experiments are planned to determine whether it is necessary to take a small amount of riboflavin in order to start the manufacturing process in operation.

Mosquitoes carry not only human diseases but also equine encephalomyelitis, at present an incurable disease in horses; animals may be protected from it by vaccination with a chick-embryo vaccine developed a few years ago.

National Inventors Council Announces 34 Needed Inventions for Air War

Wanted: Engine Using 100-Octane

► A SMALL, LIGHT-WEIGHT dependable gasoline engine, rating from one to five horsepower and capable of operating on 100-octane aviation fuel, is wanted by the Army Air Forces, and ideas from the public that may contribute to the development of such an engine are requested by the National Inventors Council, Washington, D. C. Other Army needs are a high-precision, low-friction bearing that does not involve the use of balls or rollers, and a liquid or paste which will prevent the formation of ice on airplane surfaces.

These three items are among 34 needed inventions listed by the National Inventors Council, with the approval of the Army Air Forces. Several needs have to do with parachutes and parachute operation. One is for the quick release of a cargo parachute from the cargo when the cargo hits the ground. Another is for a parachute opening device that will provide automatic opening at a definite altitude above the ground. Low cost aerial delivery parachutes, better harness with

improved quick-release hardware, new canopy designs, and parachute drop test instruments are also listed and inventive ideas relative to them requested.

Material with the electrical properties and heat resistant characteristics of mica is desired in aviation. Other items listed include a simply installed thrustmeter, a shock absorber that does not require the use of synthetic packing to retain the fluid in the strut, and an automatic ground speed measuring device.

The National Inventors Council, organized in the U. S. Department of Commerce, was created in 1940 to receive and handle inventive ideas submitted by citizens to help win the war. It has a staff of engineers and other experts, and a system of technical committees, so that useful ideas may be quickly evaluated and put in the hands of the proper military and naval divisions. Inventive ideas are wanted by it in all fields and not in aviation alone.

Additional carbon tetrachloride is now available for dry cleaning purposes as military needs no longer require the entire output.

The textiles of ancient Peru include every type of weaving known to the modern world and some types not known today; the finest ancient Peruvian fabrics have 270 threads to the inch.

Felt, used as a filter to safeguard the respiratory systems of workers exposed to dust and fumes, was selected after tests made by passing tobacco smoke through it and comparing the strained and the unstrained smoke.

The Coming of Melamine Moldings

► FIFTEEN YEARS AGO moldings came out of mourning, thanks to the development of water-clear urea-formaldehyde resins, permitting moldings of translucent white and pastel shades of gay and luminous beauty.

Discovery that melamine—one of the descendants on the family tree of calcium cyanamide—can be condensed with certain aldehydes to produce resinous products, has been followed by the development of moldings with a color range as wide as that of urea moldings, and with superior technical properties.

Melamine resin is colorless and water-clear when made from pure materials. It is hydrophilic and miscible with water and water-alcohol mixtures. When subjected to heat, or under the influence of certain chemicals, it becomes insoluble, in fusible, and very hard. This change can occur over wide ranges of acidity or basicity, in contrast to other thermo-setting resins. As a result, melamine resins can be used in combination with either mineral or cellulosic fillers for molding compositions and laminated articles.

Melamine resin with a finely divided filler of wood pulp—alpha cellulose—may be molded into buttons, lighting reflectors, and tableware in the same beauty as the urea resins, but with superior electrical resistance and water resistance for the special uses where those features

are important. Because it will not burn of itself and because it resists charring, it provides superior molded parts for aircraft ignition systems operating at high altitudes where arcing is increased in the rarefied air. Superior heat resistance facilitates the use of melamine moldings and laminated sheets in table tops and lighting reflectors; superior water resistance gives them preference for dishes, service trays, and buttons; superior weather resistance makes them the choice for outdoor uses.

Melamine had been known in the books and laboratories of the world since Liebig synthesized it in 1834, but its synthesis required raw materials that were relatively scarce in those days; until the merits of melamine resins were established, no one had ever seen a reason for putting melamine into commercial production. Free cyanamide, H_2CN_2 , derived from calcium cyanamide, is converted to dicyandiamide (H_2CN_2)₂ and this in turn to melamine, the sequence representing an attractively short conversion in these days when low-priced calcium cyanamide is available in great tonnages.

Melamine production is now on a tonnage basis but available for restricted applications only, and few melamine moldings are yet in civilian use.

—From "For Instance"
(American Cyanamid Co.)

The fleshy roots of the southwestern American canaigre contain from 10% to 35% of tannin on a dry weight basis; some of this is now being used in leather tanneries.

Odorless Household Fly Spray

New Postwar Anti-Insect Chemical Warfare Seen

► AN ODORLESS, nonirritating household fly spray for postwar use in homes and restaurants has been developed by W. F. Barthel, H. L. Haller and F. B. LaForge, chemists of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

Used in the aerosol "bomb" developed by the Department of Agriculture for use by the armed forces against mosquitoes, the new fly spray promises to be an effective postwar weapon against flies, roaches, bedbugs, ants, mosquitoes, house spiders, silverfish, chiggers, carpet beetle larvae, dog ticks and dog fleas. It will be suitable for use in homes, restaurants, airplanes and any place where people congregate.

The spray is made from the powerful insect-killer, pyrethrum, purified by a new method to eliminate the odor and the irritating impurities which in the past have been the cause of irritating rashes or hay fever symptoms in some pyrethrum spray users. The method involves the use of a new solvent, nitromethane, for removing prac-

tically pure pyrethrins from the impure petroleum extract of pyrethrum flowers.

The new process produces not only a much more concentrated and powerful insect poison but one in a form called "ideal" for use in the Freon-aerosol bomb. This bomb or aerosol sprayer is a small handy can dispenser that holds a liquefied gas such as Freon, which is now used in household refrigerators. When a valve is opened this aerosol dispenser emits a foglike spray of poisonous droplets so tiny that they kill more insects than ordinary coarse sprays.

While not yet available for civilian sale, Agriculture Department officials state, more than 13 million of these Freon-aerosol "bombs" have been supplied to the armed forces for use against disease-carrying insects. As a result of such extensive use, this kind of aerosol spray dispenser has been thoroughly tested and will be available for household use as soon as a commercial product can be manufactured for the home market after the war ends.

Natural Gas Harmless to Plants

► NATURAL GAS was found non-injurious to growing plants and cut flowers, in experiments by Prof. Felix G. Gustafson of the University of Michigan. In this it is radically different from manufactured gas, which has long been known to be very harmful to plants growing in homes and greenhouses, as well as to certain kinds of cut flowers.

Prof. Gustafson placed potted

plants of tomato, coleus, sunflower, snap-dragon, marigold and several other species, as well as cut flowers of tulip, carnation and stock, under bell-jars. In some of the bell-jars from one to two per cent of Texas natural gas, taken directly from the pipe line, was added to the atmosphere. Other jars were left with only ordinary air in them, as controls.

Fever Chemical Discovered

➤ **DISCOVERY** of a chemical that apparently is the cause of the fever that comes with inflammations is announced by Dr. Valy Menkin, of Duke University School of Medicine, Durham, North Carolina. It is a nitrogen-containing substance which Dr. Menkin has christened pyrexin, following the medical custom of using the word pyrexia, borrowed from the Greek, for fever.

Pyrexin was obtained from inflammatory discharges such as that in pleurisy. Blood serum containing hemoglobin from ruptured red blood cells also contains the chemical. This suggests that pyrexin is liberated from

red cells ruptured in the course of injury or disease. The chills and fever of malaria may be due in part at least to release of pyrexin from the red cells.

Boiling does not destroy the fever-inducing action of pyrexin and tests with mice and rabbits show that it is not injurious to animal tissues. It may, therefore, be valuable in treating central nervous system disorders, for example, Dr. Menkin suggests, for fever treatment of syphilis of the central nervous system. Pyrexin's mode of action, he believes, may be on fever centers in the hypothalamic region of the brain.

Powerful Blood-Clotting Substance

➤ **BLOOD-CLOTTING** almost instantly results from the use of a powerful natural substance, a great new life-saver for peacetime surgery as well as in war wounds, developed in the laboratories of Parke, Davis and Company, Detroit, by Drs. Walter H. Seegers, Eugene C. Loomis and J. M. Vandenbelt.

Nature's own blood-clotting mechanism is duplicated in the new process reported to the American Chemical Society.

It takes the two main materials from animal blood and from meat juices, thus making unlimited production possible. The blood-clotting substance is prothrombin, found in

human blood. It has not been isolated in virtually pure form by these three men after six years of effort.

Prothrombin by itself, they said, is entirely inert or inactive just as it is in the normal circulating blood stream. But when living tissue is injured, it releases an activator that sets off nature's blood-clotting mechanism. The prothrombin and calcium in blood react with the activator to initiate the formation of a clot at the wound and stop the bleeding.

The investigators extracted this activator from meat juices and made animal-blood prothrombin active by combining it with the precise amount of calcium ion and with the precise amount of activator.

Larger quantities of domestic wool, the production of better grades, and the adoption of improved weaving practices, are now making Brazil independent of foreign wool-textiles.

Magnesium For Household Appliances

► WIDESPREAD use of magnesium, the lightweight metal, in postwar commercial and consumer products is predicted by R. P. Lansing, vice president of Bendix Aviation Corporation.

The major problems of fabricating magnesium have been solved by wartime research, so that the metal can

be used in such applications as knitting machines, bread-slicing machines, household appliances, portable hand tools, radios, cameras, and other items.

Today, magnesium is extracted from sea water and inland magnesium ore for use in castings, airplane parts, and other war materiel.



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"Lemonadel—Contains vitamins an' iron an' calcium an' niacin 'r something."

Chemical Things to Do

Solid Alcohol For Tin Can Stove

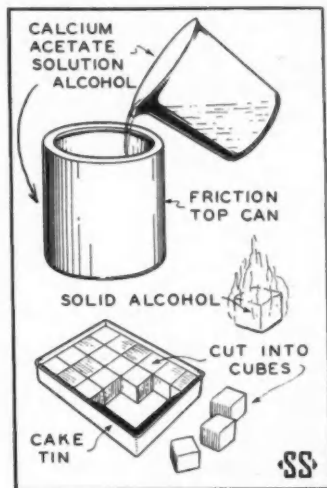
by JOSEPH H. KRAUS, *Science Clubs of America Editor*

► **JELLY-LIKE CUBES** of alcohol, which will burn freely, are excellent for cooking hot dogs or brewing a pot of coffee in a tin can stove when on an outing. The material can be packed into small space and will not add greatly to the weight of your camping equipment. In gelatinous form the alcohol cannot spill.

A tin can may be pressed into service as a stove. Make two vertical cuts about two inches long and two inches apart, cutting down from the open end of the can. Fold the flap inward. Now turn the can upside down and punch a few holes just under the closed end. This is for air circulation in your stove. The cooking pot or skillet may then be rested on the closed end of this tin can stove.

You can easily make solid alcohol blocks, or a can of solid alcohol. Ask your local druggist to secure for you four ounces of calcium acetate. Normally he does not carry this chemical in stock, but it can be procured from laboratory supply houses where four ounces is usually the smallest quantity sold. It is not expensive. Dissolve one ounce of this calcium acetate in three ounces of water.

To make the solid alcohol blocks, pour eighty-five parts of denatured alcohol, purchased from the local paint or hardware store, into a cake pan or some other shallow pan. Anything such as a teaspoon, tablespoon, glass or graduated cylinder can be used for



measuring. Stir the alcohol and at the same time pour in fifteen parts of the calcium acetate solution. Continue stirring until you have a thick, jelly-like mass.

Cut Into Blocks

Cut the jelly into blocks of convenient size, just as you would fudge candy. Remove the blocks and drop into an air-tight metal container for subsequent use. Label it "Poison." This material should not, of course, be eaten.

If you prefer to make your solid alcohol in a can, use a clean tin can with a pry-open type of lid. In this

case you don't have to bother to cut the jelly into blocks, but can just snap the lid into position. The air-tight can offers a convenient way for carrying the solid alcohol with you, at the same time preventing it from evaporating.

To use the solid alcohol blocks, set the tin can stove on a stone. Slide one of the cubes in through the opening in the side of the can and light it. It will produce a hot flame. Put in only one brick at a time. When the heat

dies down, add another. Always cover the reserve stock to avoid evaporation. Do not try to extinguish the flame of the alcohol cubes; instead, let them burn out.

If the alcohol was mixed in a small tin can, pry open the lid, put the entire can into your "stove" and light with a match. In this case, when the flame is to be extinguished, merely slip the lid on the can through the side opening of your stove.

Chem Quiz

Do They Mean What They Say?

► WHEN ROOTS of words and chemical prefixes and suffixes get together, the result sometimes adds joy to the chemist's vocabulary. How many of these have you run across in your lab?

Example: If a certain metal were called by its common name, which of its oxides would be cruelly humorous?

Ans.: Fe_2O_3 , iron oxide.

Unlike the example above, all the following questions are to be answered by the ordinary names of the compounds asked for. Correct answers on page 42.

1. Which acid must belong in the

Table?

2. Which acid is colossal?
3. Which acid strives to improve the human race?
4. Which acid has heavenly associations?
5. Which mineral should you take to your Christmas dinner?

Count 20 for each correct answer.

If you score 60 you are a pretty good chemist, 80 you are as good as the acid in No. 2, 100 you are the answer to No. 4, or else you, too, have just read the dictionary.

DuPont Chemical Director Awarded Perkin Medal

► DR. ELMER K. BOLTON, chemical director of E. I. duPont de Nemours & Co., Wilmington, Del., will be presented the Perkin medal on January 5 by the American section of the Society

of Chemical Industry in recognition of his industrial research accomplishments. He will be the 39th chemist to receive this medal, one of the major awards in American chemistry.

Chemical Patents of the Month

AMONG the several thousand patents issued by the U. S. Patent Office each month there are many devoted to chemical processes and apparatus. Some of them are reported in this article. Anyone may obtain a copy of a patent by sending 10 cents in coin (not stamps) to the Commissioner of Patents, Washington, D. C., and asking for the patent by number.

Saving Chemical Dusts

➤ **SAVING** valuable dusts, in such industries as smelting and cement manufacturing, is the chemical analogue of the meat packers' traditional "using even the squeal." Two new inventions are devoted to this profitable purpose.

Both devices operate on the centrifugal principle, whirling dust-laden air or flue gases through narrow spaces, so that the particles are stopped by the walls and drop through discharge openings at the bottom. They differ, however, in internal arrangement.

One of the dust separators, invented by C. B. McBride of Port Chester, N. Y., and J. E. Watson of Westport, Conn., sets the dusty gases spinning through a series of tall, small-diameter tubes, somewhat similar to organ pipes. The small amounts of very fine particles that survive this primary centrifugal separation are finally removed in a supplemental separator where they are trapped either by a high-tension electric field or by a liquid spray. Rights in the patent, No. 2,360,355, are assigned to the Prat-Daniel

Corporation of Port Chester, N. Y.

The other de-dusting device, on which patent 2,360,498 has been granted to C. L. Howse of Birmingham, Mich., consists of a series of larger cylinders nested one within the other so that a series of narrow, annular spaces is left between them. The dust-laden gases are set spinning through these spaces, losing their load as the particles strike the successive walls. The Diamond Power Specialty Corporation of Detroit is assignee of rights in this patent.

Coffee Flavor Sealed in Syrup

➤ **CHEMISTRY** of a more personally appealing sort is embodied in patent 2,360,342, obtained by W. A. Heyman of New York City on a process for extracting all the flavor of fresh-roasted coffee and sealing it against staling within the particles of a solidified corn syrup. The various substances that together give coffee its flavor are extracted from the freshly roasted beans by steam and vacuum treatments, followed by centrifuging. They are introduced into corn syrup, which is subsequently "expanded" by steam or gas action and then dehydrated and powdered. The powder may be prepared for beverage use simply by adding hot water. Patent rights have been assigned to Granular Foods, Inc., of New York City.

Simplified, Lighter Respirator

➤ **APPARATUS** for maintaining artificial respiration, of simpler and less rigid

construction than those now in use, as well as lighter in weight and lower in cost, is claimed by F. O. Church of Buffalo, N. Y., in his description of patent 2,360,476. For the stiff corselet of molded plastic or metal now in common use, he substitutes a strong but light layer of rubberized fabric, reinforced with a few longitudinal rods. Close contact with the patient's body is maintained by means of a marginal cushion of foamed latex rubber. Patent rights are assigned to the Dunlop Tire and Rubber Corporation.

Shell Band

▶ A SELF-LUBRICATED driving band for artillery projectiles is covered by patent 2,360,473 granted to W. G. Calkins of Detroit, assignor to the Chrysler Corporation. In place of the solid ring of soft copper conventionally used, it consists of a ring of sintered copper alloy impregnated with graphite and other lubricating materials, the whole being bonded to a backing ring of steel which secures it to the shell.

Porcelain Bombs

▶ AN AERIAL BOMB made of porcelain is the somewhat Chinese-sounding proposal advanced by James D. Long of Laurel, Md., in obtaining patent 2,360,696. The idea is to conserve metal, and at the same time obtain an effective, low-cost fragmentation missile. Shrapnel pellets, which may also be made of porcelain, are optional inclusions within the explosive charge.

Fuel Control Devices

▶ ONE FUEL control device recently patented is a photoelectric-control automatic fuel shut-off for home oil and gas furnaces, claimed to be an improvement on earlier somewhat similar devices. Another of particular interest

saves fuel in large internal combustion engines by preventing them from running after the ignition has been shut off, a more or less common occurrence, due to pre-ignition, in aircraft, war tank, and other engines.

In the automatic fuel shutoff using the photoelectric control, light from the flame inside the combustion chamber in the furnace passes out through a small tubular opening in the front of the furnace to a photoelectric cell. The axis of the tubular opening and the axis of the flame are at an angle of from 30 to 45 degrees to each other as this gives the best results. When the light is cut off for any reason the cell actuates an electric control that operates a valve that regulates the flow of the fuel to the burner. It operates when the flame becomes extinguished, or if the mixture of fuel and air becomes too lean or too rich, thus decreasing the strength of the light. Patent 2,360,166 was granted this device to Alfred F. Schumann of Lower Merion, Pa., and Alexander J. Turpin, Stewart Manor, N. Y., assignors to the Hauck Manufacturing Co., Brooklyn, N. Y.

The fuel control for internal combustion engines consists of a solenoid, which acts like an electromagnet, placed inside the housing of the degasser used in connection with the carburetor on heavy engines. When electrically energized, the solenoid operates a walking beam or lever and closes a throttle valve. The electric current to the solenoid is controlled by a switch on the dashboard. The patentee is William E. Leibing, Detroit, Mich., who is assignor to Leibing-Fageol Co., of the same city. The patent is number 2,359,925.

Water Treating Plant

► A WATER TREATING plant, to treat water chemically, particularly for boilers but suitable for treating water for other purposes, permits satisfactory treatment automatically regardless of the varying pressure on the water in the supply mains. The chemical treatment varies directly with the amount of water passing through a meter and into the treatment tank.

The meter used includes a propeller driven in direct proportion to the rate at which the water flows through the pipe and "counts" the number of gallons of water passing. By means of a cam operated after a certain volume of water has passed, an electric circuit is closed, causing a chemical reagent in liquid form to be added to the water.

The patent, 2,359,991, is assigned to the Dearborn Chemical Co. of Chicago by the patentee, Walter H. Hinsch, also of Chicago.

Electrical Resistance Alloy

► AN ELECTRICAL resistance alloy containing nickel, chromium, aluminum and iron, granted patent 2,359,781, was developed to replace the more common nickel-chromium alloy used for electrical resistance in electrical instruments because of the relatively high cost of these metals and their scarcity under war conditions. The new alloy uses only a small amount of these two metals, inexpensive iron making up the bulk of the mixture.

Theobald H. Noll, Washington, D. C., who received the patent, uses in his alloy 4 per cent of nickel by weight, 14.3 per cent of chromium, 2.6 per cent of aluminum, and the rest iron. The iron, nickel and chromium

are fused together first, and then the aluminum is added. The function of the aluminum is to improve the iron's resistance to corrosion.

Cutting Sheet Aluminum

► CLEAN NARROW cuts in sheet or plate aluminum, magnesia, or alloys of light metals, are obtained, it is claimed, by using a hand dual-nozzle heating device with an attached cutter. A single holder contains the two nozzles for gaseous flames and the cutting blade. The first nozzle with its flame is very close to the metal sheet to be cut, and the second nozzle, between the first and the cutter, is slightly farther away from the metal so that the blade itself is protected from the heat.

In operation, the device is moved forward over the metal along the line to be cut, with the cutting blade following the flames. The heat softens the metal sufficiently so that the blade cuts through. The edges of the cut are not distorted and no material is wasted as occurs when aluminum is cut with the oxyacetylene flame. The patent, number 2,358,772, was issued to George F. Brow of East Braintree and Frank E. Rioux of North Attleboro, both in Massachusetts.

New Water Gas Process

► A MODIFIED method of manufacturing water gas, the mixture of carbon monoxide and hydrogen that forms a large part of fuel gas used in many cities, has been patented. Conventionally, this is made by first heating ignited coke or other solid fuel to incandescence, then running steam through it. The steam is "cracked," takes up some carbon, and emerges as water gas. This is then mixed with a suitable proportion of oil gas, made

by trickling oil over white-hot fire-brick.

The new process, on which C. W. Hunter of Haverford, Pa., and J. S. Haug, of Philadelphia have obtained patent 2,361,292, is designed particularly for use in regions where oil or other liquid fuels are cheap. Oil is introduced into the top of the generator before the steam is turned on. Part of it burns, producing heat in the solid fuel bed, and part of it is cracked into oil gas which becomes part of the watergas-oilgas mixture later sent into the mains. Patent rights have been assigned to United Engineers and Constructors, Inc.

Naphtha Into Aviation Gasoline

► CATALYTIC chemistry scores another advance in the process on which Alexis Voorhies, Jr., of Baton Rouge, La., was granted patent 2,361,138, which is assigned to Standard Catalytic Company. It consists in the cracking of naphtha and the rearrangement of its atomic fragments into aviation gasoline, in the presence of a synthetic silica alumina catalyst, at pressures around 250 pounds per square inch and a temperature of 958 degrees Fahrenheit.

Rubber Patents

► SEVERAL patents on rubber and its products have been assigned to the B. F. Goodrich Company by their inventors. One, covering a new type of synthetic rubber, is covered by patent 2,360,864, issued to C. F. Fryling of Silver Lake, Ohio. It is on a synthetic rubber composition consisting of a butadiene-acrylonitrile copolymer, with the addition of dibutyl meta cresol or a related compound to impart the necessary degree of tackiness. This

tackiness or stickiness is necessary in the successful fabrication of the rubber; it has been difficult to obtain with previously used materials.

Leak-Proof Rubber

► RUBBER TIRES, gasoline tanks, hot-water bottles and similar articles are made proof against leakage of either air or liquids by a double-walled, plastic-bonded construction on which Edwin T. Wyman of Brookline, Mass., has taken out patent 2,360,925. The plastic between the two bounding layers of vulcanized rubber automatically seals incipient leaks and small punctures and prevents their becoming more serious.

Water-Vapor Strengthens Steel

► USE OF WATER-VAPOR in the atmosphere in which steel is heat-treated to increase its strength is the central idea in patent 2,360,868, assigned by the inventor, Maxwell Gensamer of Pittsburgh, to the Carnegie-Illinois Steel Corporation. The atmosphere commonly in use includes hydrogen; but Mr. Gensamer has found that the addition of water-vapor tends to abate the graininess of the metal and greatly reduce its yield point.

Carbon Dioxide In Ice

► CARBON DIOXIDE, which makes many of our beverages fizzy, is added to the ice that makes them cold, in the invention on which patent 2,361,137 was issued to K. F. Terry of San Francisco and J. J. Imperatrice of Fresno. The gas is simply bubbled through the water as it is frozen into ice, and a considerable fraction thereby trapped until the ice again thaws.

In addition to improving the quality of beverages in which this carbonated

ice is used, it has a further advantage when employed in the refrigeration of fruit and vegetables, the inventors claim. They point out that the release of carbon dioxide in the storage space slows down the oxidative deterioration of the living cells in the stored plant materials.

Smoother Soaps

► SMOOTHER soaps, more suavely scented, are expected to be obtainable from foul-smelling greases and rancid oils hitherto considered hopeless as sources, through a new process for distilling fatty acids on which U.S. patent 2,361,411 has just been issued here, to John F. Murphy of Fitchburg, Mass.

All ordinary oils and fats, including the kitchen wastes which housewives are now urged to save, split chemically into two main components: glycerin and one or more fatty acids. The latter, combined with a mild alkali, become soap.

Many salvaged greases and oils contain extraneous substances that impart disagreeable odors and bad colors, ruining their chances of being utilized in high-grade soaps. To get rid of them, Mr. Murphy's process first distills the crude soap stock under a moderate vacuum. This takes off the more volatile of the malodorous substances. Then the vacuum is increased, and the desired fatty acids themselves distill off, leaving behind the heavier, ranker compounds of lower boiling point.

Rights in the patent are assigned to a well-known soap-making firm, Lever Brothers Company.

"Puffed" Plastics

► To MAKE thermosetting plastics

lighter in weight for certain purposes, Philip S. Turner of Williamsport, Pa., has applied to them the puffed-grain principle, long familiar in breakfast-cereal manufacture, in a process on which he has received patent 2,361,438. Moist starch grains are mixed with the plastic mass. When heat is applied, the water turns into steam, which puffs innumerable little cavities into the matrix. When the plastic cools and sets, the water condenses, but the lightening cavities remain.

Improvement in Zein Fiber

► FOR AN IMPROVEMENT in the method of making artificial fibers out of zein, the protein found in corn, O. C. H. Sturken of Closter, N. J., has been awarded patent 2,361,713. Zein fibers can be hardened from their doughy dissolved state by passing them through a formaldehyde bath, the inventor explains. However, they still remain somewhat tacky, tending to stick together. He overcomes this difficulty by mixing a quantity of diatomaceous earth or finely ground bone in the formaldehyde solution.

Platinum Alloy for Glass Works

► A NEW PLATINUM-NICKEL alloy, designed especially for use in manipulating liquid glass, is the subject of patent 2,361,578, issued to M. B. Vilensky of Newark, Ohio, assignor to the Owens-Illinois Glass Company. In working liquid glass, especially in the manufacture of glass filaments and fibers, a platinum-rhodium alloy has been much used. This has the disadvantage of high cost, primarily because of the scarcity of rhodium; the latter metal also tends to evaporate out of the alloy on prolonged exposure to high temperatures. Mr. Vilensky has

found that an alloy of 95 per cent to 99.5 per cent platinum with 5 per cent to 0.5 per cent nickel gives very satisfactory service at a lower over-all cost.

Luminescent Cadmium

► FOR PRODUCING light from non-luminous ultraviolet radiations, Harry M. Fernberger of Cleveland Heights, Ohio, uses cadmium tungstate, with bismuth and samarium as activators. Rights in the patent, No. 2,361,467, have been assigned to the General Electric Company.

Cadmium in Camouflage

► CADMIUM is used also in a new camouflage paint, on which patent 2,361,473 has been issued to W. C. Granville of New York City, assignor to the Interchemical Corporation. Use of a cadmium compound for this purpose is important, the inventor states, because of the increasing use of infra-red plates in aerial photography. These easily distinguish between the green of natural foliage and ordinary green paints because the latter reflect little infra-red radiation.



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It's a special ragweed shell to knock out the hay fever guys in the enemy's ranks!"

Classics of Chemistry:

The Original Discovery of Hydrogen and the Announcements of its Isotopes

The Three Hydrogens

► THE EXPERIMENTS on hydrogen which Cavendish performed for the first time, here related by him, are now among the first exercises in chemistry for beginners. You can repeat them easily, but it is as well to be as cautious about getting hurt as Cavendish was. Bottles containing hydrogen-air mixtures have been known to break since his time.

Hydrogen since the time of Cavendish has come to be considered not only the lightest possible element but one of the ultimate constituents of all matter. The discovery in 1931 that it has an isotope of atomic weight 2 led to re-measuring all sorts of materials containing hydrogen, even water.

The third hydrogen is exceedingly rare, and is radioactive.

Inflammable Air

EXPERIMENTS ON FACTITIOUS AIR, by the Hon. Henry Cavendish, F.R.S. in *Philosophical Transactions of the Royal Society of London*, Vol. 56, Read May 29. 1766.

► I KNOW of only three metallic substances, namely, zinc, iron and tin, that generate inflammable air by solution in acids; and those only by solution in the diluted vitriolic acid, or spirit of salt.

Zinc dissolves with great rapidity in both these acids; and, unless they are very much diluted, generates a considerable heat. One ounce of zinc produces about 356 ounce measures of air: the quantity seems just the same whichever of these acids it is dissolved in. Iron dissolves readily in the diluted vitriolic acid, but not near so readily as zinc. One ounce of iron wire produces about 412 ounce measures of air: the quantity was just the same, whether the oil of vitriol was diluted with $1\frac{1}{2}$, or 7 times its weight of water: so that the quantity of air produced

seems not at all to depend on the strength of the acid.

Iron dissolves but slowly in spirit of salt while cold: with the assistance of heat it dissolves moderately fast. The air produced thereby is inflammable; but I have not tried how much it produces.

Tin was found to dissolve scarcely at all in oil of vitriol diluted with an equal weight of water, while cold: with the assistance of a moderate heat it dissolved slowly, and generated air, which was inflammable: the quantity was not ascertained.

Tin dissolves slowly in strong spirit of salt while cold: with the assistance of heat it dissolves moderately fast. One ounce of tinfoil yields 202 ounce measures of inflammable air.

These experiments were made, when the thermometer was at 50° and the barometer at 30 inches.

All these three metallic substances dissolve readily in the nitrous acid,

and generate air; but the air is not at all inflammable. They also unite readily, with the assistance of heat, to the undiluted acid of vitriol; but very little of the salt, formed by their union with the acid, dissolves in the fluid. They all unite to the acid with a considerable effervescence, and discharge plenty of vapors, which smell strongly of the volatile sulphureous acid, and which are not at all inflammable. Iron is not sensibly acted on by this acid, without the assistance of heat; but zinc and tin are in some measure acted on by it, while cold. . . .

Inflammable Air

I now proceed to the experiments made on inflammable air.

I cannot find that this air has any tendency to lose its elasticity by keeping, or that it is at all absorbed, either by water, or by fixed or volatile alkalies; as I have kept some by me for several weeks in a bottle inverted into a vessel of water, without any sensible decrease of bulk; and as I have also kept some for a few days, in bottles inverted into vessels of sope leys and spirit of sal ammoniac, without perceiving their bulk to be at all diminished.

It has been observed by others, that, when a piece of lighted paper is applied to the mouth of a bottle, containing a mixture of inflammable and common air, the air takes fire, and goes off with an explosion. In order to observe in what manner the effect varies according to the different proportions in which they are mixed, the following experiment was made.

Some of the inflammable air, produced by dissolving zinc in diluted oil of vitriol, was mixed with common

air in several different proportions, and the inflammability of these mixtures tried one after the other in this manner. A quart bottle was filled with one of these mixtures. The bottle was then taken out of the water, set upright on a table, and the flame of a lamp or piece of lighted paper applied to its mouth. But, in order to prevent the included air from mixing with the outward air, before the flame could be applied, the mouth of the bottle was covered, while under water, with a cap made of a piece of wood, covered with a few folds of linen; which cap was not removed till the instant that the flame was applied. The mixtures were all tried in the same bottle; and, as they were all ready prepared, before the inflammability of any of them was tried, the time elapsed between each trial was but small: by which means I was better able to compare the loudness of the sound in each trial. The result of the experiment is as follows.

Effect of Mixture with Air

With one part of inflammable air to 9 of common air, the mixture would not take fire, on applying the lighted paper to the mouth of the bottle; but on putting it down into the belly of the bottle, the air took fire, but made very little sound.

With 2 parts of inflammable to 8 of common air, it took fire immediately, on applying the flame to the mouth of the bottle, and went off with a moderately loud noise.

With 3 parts of inflammable air to 7 of common air, there was a very loud noise.

With 4 parts of inflammable to 6 of common air, the sound seemed very little louder.

With equal quantities of inflammable and common air, the sound seemed much the same. In the first of these trials, namely, that with one part of inflammable to 9 of common air, the mixture did not take fire all at once, on putting the lighted paper into the bottle; but one might perceive the flame to spread gradually through the bottle. In the three next trials, though they made an explosion, yet I could not perceive any light within the bottle. In all probability, the flame spread so instantly through the bottle, and was so soon over, that it had not time to make any impression on my eye. In the last mentioned trial, namely, that with equal quantities of inflammable and common air, a light was seen in the bottle, but which quickly ceased.

With 6 parts of inflammable to 4 of common air, the sound was not very loud: the mixture continued burning a short time in the bottle, after the sound was over.

With 7 parts of inflammable to 3 of common air, there was a very gentle bounce or rather puff: it continued burning for some seconds in the belly of the bottle.

A mixture of 8 parts of inflammable to 2 of common air caught fire on applying the flame, but without any noise: it continued burning for some time in the neck of the bottle, and then went out, without the flame ever extending into the belly of the bottle.

It appears from these experiments, that this air, like other inflammable substances, cannot burn without the assistance of common air. It seems too, that, unless the mixture contains more common than inflammable air, the

common air therein is not sufficient to consume the whole of the inflammable air; whereby part of the inflammable air remains, and burns by means of the common air, which rushes into the bottle after the explosion.

Air from Different Metals

In order to find whether there was any difference in point of inflammability between the air produced from different metals by different acids, five different sorts of air, namely, 1. Some produced from zinc by diluted oil of vitriol, and which had been kept about a fortnight; 2. Some of the same kind of air fresh made; 3. Air produced from zinc by spirit of salt; 4. Air from iron by the vitriolic acid; 5. Air from tin by spirit of salt; were each mixed separately with common air in the proportion of 2 parts of inflammable air to $7\frac{7}{10}$ of common air, and their inflammability tried in the same bottle, that was used for the former experiment, and with the same precautions. They each went off with a pretty loud noise, and without any difference in the sound that I could be sure of. Some more of each of the above parcels of air were then mixed with common air, in the proportion of 7 parts of inflammable air to $3\frac{1}{2}$ of common air, and tried in the same way as before. They each of them went off with a gentle bounce, and burnt some time in the bottle, without my being able to perceive any difference between them.

In order to avoid being hurt, in case the bottle should burst by the explosion, I have commonly, in making these sort of experiments, made use of an apparatus contrived in such manner, that, by pulling a string, I drew

the flame of a lamp over the mouth of the bottle, and at the same time pulled off the cap, while I stood out of the reach of danger. I believe, however, that this precaution is not very necessary; as I have never known a bottle to burst in any of the trials I have made.

Weight of Inflammable Air

The specific gravity of each of the above-mentioned sorts of inflammable air, except the first, was tried in the following manner. A bladder holding about 100 ounce measures was filled with inflammable air and the air pressed out again as perfectly as possible. By this means the small quantity of air remaining in the bladder was almost intirely of the inflammable kind. 80 ounce measures of the inflammable air, produced from zinc from the vitriolic acid, were then forced into the bladder in the same manner: after which, the pewter pipe was taken out of the wooden cap of the bladder, the orifice of the cap stopt up with a bit of lute,¹ and the bladder weighed. A hole was then made in the lute, the air pressed out as perfectly as possible, and the bladder weighed again. It was found to have increased in weight $40\frac{3}{4}$ grains. Therefore the air pressed out of the bladder weighs $40\frac{3}{4}$ grains less than an equal quantity of common air: but the quantity of air pressed out of the bladder must be nearly the same as that which was

forced into it, i.e. 80 ounce measures: consequently 80 ounce measures of this sort of inflammable air weigh $40\frac{3}{4}$ grains less than an equal bulk of common air. The three other sorts of inflammable air were then tried in the same way, in the same bladder, immediately one after the other. In the trial with air from zinc by spirit of salt, the bladder increased $40\frac{1}{2}$ grains on forcing out the air. In the trial with the air from iron, it increased $41\frac{1}{2}$ grains, and in that with the air from tin, it increased 41 grains. The heat of the air, when this experiment was made, was 50° ; the barometer stood at $29\frac{3}{4}$ inches.

There seems no reason to imagine, from these experiments, that there is any difference in point of specific gravity between these four sorts of inflammable air; as the small difference observed in these trials is in all probability less than what may arise from the unavoidable errors of the experiment. Taking a medium therefore of the different trials, 80 ounce measures of inflammable air weigh 41 grains less than an equal bulk of common air. Therefore, if the density of common air, at the time when this experiment was tried, was 800 times less than that of water, which, I imagine, must be near the truth, inflammable air must be 5490 times lighter than water, or near 7 times lighter than common air. But if the density of common air was 850 times less than that of water, then would inflammable air be 9200 times lighter than water, or $10\frac{8}{10}$ lighter than common air. . . .

None from Copper

I made an experiment with design to see whether copper produced any inflammable air by solution in spirit

¹ The lute used for this purpose, as well as in all the following experiments, is composed of almond powder, made into a paste with glue, and beat a good deal with a heavy hammer. This is the strongest and most convenient lute I know of. A tube may be cemented with it to the mouth of a bottle, so as not to suffer any air to escape at the joint; though the air within is compressed by the weight of several inches of water.

of salt. I could not procure any inflammable air thereby: but the phenomena attending it seem remarkable enough to deserve mentioning. The bottle was filled almost full of strong spirit of salt, with some fine copper wire in it. The wire seemed not at all acted on by the acid, while cold; but, with the assistance of a heat almost sufficient to make the acid boil, it made a considerable effervescence, and the air passed through the bent tube, into the [receiving] bottle pretty fast, 'til the air forced into it by this means seemed almost equal to the empty space in the bent tube and the bottle: when, on a sudden, without any sensible alteration of heat, the water rushed violently through the bent tube into the [first] bottle, and filled it almost intirely full.

The experiment was repeated again in the same manner, except that I took away the [receiving] bottle, and let out some of the water of the cistern: so that the end of the bent tube was out of water. As soon as the effervescence

began, the vapours issued visibly out of the bent tube; but they were not at all inflammable, as appeared by applying a piece of lighted paper to the end of the tube. A small empty phial was then inverted over the end of the bent tube, so that the mouth of the phial was immersed in the water, the end of the tube being within the body of the phial and out of water. The common air was by degrees expelled out of the phial, and its room occupied by the vapours; after which, having chanced to shake the inverted phial a little, the water suddenly rushed in, and filled it almost full; from thence it passed through the bent tube into the first bottle, and filled it quite full. It appears likely from hence that copper, by solution in the marine acid, produces an elastic fluid, which retains its elasticity as long as there is a barrier of common air between it and the water, but which immediately loses its elasticity, as soon as it comes in contact with the water.

Deuterium

HYDROGEN ATOMS OF TWICE USUAL WEIGHT DISCOVERED

*The Science News Letter, Vol. XX,
No. 558, December 19, 1931.*

► HYDROGEN atoms twice as heavy as usual, forming probably a new unit in the building of all other chemical atoms and throwing new light on the mystery of the atom core, have been detected for a first time through the collaboration of Prof. Harold C. Urey and Dr. G. M. Murphy of Columbia University with Dr. F. G. Brickwedde of the U. S. Bureau of Standards.

The low temperature laboratory of the Bureau, in which liquid helium was made for the first time in the United States some months ago by Dr. Brickwedde and others, assisted in the discovery of this new hydrogen isotope, which differs from ordinary hydrogen only in the weight of its atoms. By evaporating liquid hydrogen under a reduced pressure, and at the excessively low temperature of freezing hydrogen 434 degrees below zero Fahrenheit, a partial separation of the heavier atoms was achieved. Prof. Urey and Dr. Murphy then examined

the heavier distillate in their spectroscopy in New York and found a new series of "Balmer" lines that could only be attributed to hydrogen atoms of atomic weight two. Only one atom out of four thousand in ordinary hydrogen gas, however, he finds, is of the new H₂ kind.

Isotope Predicted

Prof. Urey himself had predicted May last that this hydrogen isotope of weight two would be found. His conclusion was drawn from a consideration of the relations between the numbers of electrons and protons in the known atomic nuclei. Independently Prof. Herrick L. Johnson of Ohio State University and Prof. Raymond T. Birge and D. H. Menzel of the University of California had made the same prediction. Dr. Johnson followed practically the same reasoning as Prof. Urey, while Prof. Birge reached his conclusions by comparing chemical atomic weights and isotopic weights obtained direct by Dr. F. W. Aston in Cambridge, England.

Faintness of the spectrum or rainbow of the light emitted by the heavier hydrogen prevented previous seekers from observing the tell-tale lines, Prof. Urey believes. Prof. Urey did indeed observe these lines in the spectrum of ordinary hydrogen gas but they were so faint that he could not be sure they were not "ghost" lines caused by irregularities in the apparatus used for detecting them. When in the low temperature experiments the proportion of the rare isotope was raised to 1 in 800, however, the H₂ lines became visible near the regular lines of the "Balmer" spectrum. The nucleus of the new atom lies in weight between ordinary hydrogen, weight one, and helium, weight four, both of them regarded as the units of which the cores of all other atoms are made. The new H₂ provides a new building block for atom nuclei, believes Dr. Brickwedde, and will be investigated with great eagerness by both chemists and physicists for the light it will throw on the structure of the nucleus.

Tritium

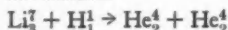
THE NEW HYDROGEN. By Lord Rutherford. In *Nature*, Vol. 133, No. 3361, March 31, 1934, p. 483.

Transmutation of Elements

► THE DISCOVERY of heavy hydrogen has provided us with a new form of projectile which has proved markedly efficient in disintegrating a number of light elements in novel ways. It was a very fortunate coincidence that, when Prof. Lewis had prepared some concentrated diplogen, his colleague in the same University, Prof. Lawrence, had available his ingenious apparatus

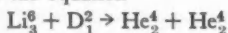
for producing high-speed protons and other particles with an energy as high as two million volts. When diplogen was substituted for hydrogen, the diplogen (D^+) was found to be about ten times as efficient in promoting some transformations in lithium as H^+ of equal energy. It will be remembered that Cockcroft and Walton found two years ago that lithium, when bombarded with fast protons, was transformed, with the emission of swift α -particles. It seems clear that in this case the lithium isotope of mass 7 is

involved. A proton is captured by the nucleus and the resulting nucleus breaks up into two α -particles, ejected in nearly opposite directions, according to the relation



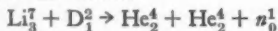
The emission of other particles of short range has also been observed but the exact nature of the transformation which gives rise to them is not yet clear.

When lithium is bombarded with diplons instead of protons, different types of transformation occur. In one case it seems that the lithium isotope of mass 6, after capturing a diplon, breaks up into two α -particles according to the equation



In this case also, as has been shown beautifully by the expansion photographs obtained by Dee and Walton, the two α -particles are shot out in opposite directions and with a speed greater than the swiftest α -particle from radioactive substances.

Still another interesting type of complex transformation occurs in this element. Oliphant and Rutherford observed that lithium when bombarded by diplons gave, in addition to the group of fast α -particles, first observed by Lawrence, a distribution of α -particles of all ranges from 7.8 cm. to 1 cm. in air. It is believed in this case that the isotope of mass 7 captures a diplon and then breaks up into two α -particles and a neutron according to the relation



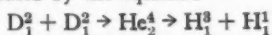
This transformation is in close accord with the conservation of energy when the change of mass and the energies of the expelled particles are taken into

account. The emission of neutrons from lithium has been observed by Lauritsen and also in our experiments. In addition, Lawrence has shown that a number of other light elements give rise under bombardment to groups of fast protons and in many cases also to α -particles and neutrons. While the interpretation of the experimental results is as yet only clear in a few cases, there can be no doubt that the use of heavy hydrogen will prove invaluable for extending our knowledge of transformations and thus in helping to throw light on the structure of atomic nuclei.

The importance of this new projectile in studying transformations is well illustrated by some recent experiments made in Cambridge with Oliphant and Harteck. When diplons were used to bombard compounds like ammonium chloride, NH_4Cl , and ammonium sulphate, $(\text{NH}_4)_2\text{SO}_4$, in which ordinary hydrogen was in part displaced by diplogen, enormous numbers of fast protons were found to be emitted, even for an accelerating voltage of 100,000 volts. In fact the number of expelled particles is far greater than that observed in any other type of transformation at this voltage. The main groups of expelled protons had a range in air of 14 cm., corresponding to an energy of 3 million volts. In addition to this group, another strong group of singly charged particles were observed of range in air only 1.6 cm. Both of these groups contain equal numbers of particles.

In order to account for these observations, it seems likely that, as the result of a close collision, the diplon occasionally unites with the struck

dipion to form a helium nucleus of mass 4 and charge 2, but containing a large excess of energy over the normal helium nucleus. The new nucleus is in consequence explosive and breaks up into two parts, one a fast proton and the other a new isotope of hydrogen H_1^3 of mass 3. If this be the case, the proton and H^3 nucleus should fly apart in opposite directions. It can be simply calculated that the range of the recoiling H^3 nucleus under these conditions should be 1.7 cm.—a range agreeing closely with that actually observed. The changes occurring are illustrated by the equation



From the known masses of D and H^1 and the energy of the observed motion of the H^1 and H^3 particles, it can be deduced that the mass of this new hydrogen isotope is 3.0151.

Radioactive Hydrogen

HELIUM AND HYDROGEN OF MASS 3. By Luis W. Alvarez and Robert Cornog, Radiation Laboratory,

Department of Physics, University of California, Berkeley, Calif. In Physical Review, Vol. 56, No. 6, Sept. 15, 1939, p. 613.

► . . . SINCE we have shown that H^3 is stable, it seemed worth while to search for the radioactivity of H^3 . We have therefore bombarded deuterium gas with deuterons, and passed the gas into an ionization chamber connected to an FP-54 amplifier. The gas showed a definite activity of long half-life. We have now shown that this gas has the properties of hydrogen by circulating it through active charcoal cooled in liquid nitrogen and allowing it to diffuse through hot palladium. The radiation emitted by this hydrogen is of very short range as was shown by the almost linear form of the intensity *vs.* pressure curve when the gas was pumped out of the chamber. When sufficient time has elapsed for us to make some statement regarding the half-life of this activity, we will submit the details of the work to this journal for publication.

Who's Who Among The Hydrogen Pioneers

HENRY CAVENDISH (1731-1810), after attending Cambridge University, went to live with his father, Lord Charles Cavendish, in London, and joined him in scientific researches in almost all branches of physical science. They lived in seclusion, in a house nearly filled with apparatus for their experiments. Henry became a Fellow of the Royal Society at the age of 29. When he was 35 he presented before the society the first of his papers on chemical "airs," from which the above extract is taken. In later years his researches covered electricity and meteorology as

well, and, at the age of 67, he published a memoir on "Experiments to Determine the Density of the Earth."

HAROLD CLAYTON UREY (1893-), Professor of Chemistry at Columbia University, studies the structure of atoms and their absorption spectra. He has investigated other isotopes in addition to "heavy hydrogen," for whose discovery he received the Willard Gibbs medal, the Nobel Prize, the Davy medal of the Royal Society and the Franklin medal of the Franklin Institute.

SIR ERNEST RUTHERFORD, Lord Rutherford of Nelson, (1871-1937) was born at Nelson, New Zealand. Educated there and at Cambridge University, he was at one time Professor of Physics at McGill University, Montreal. Returning to Cambridge as Cavendish Professor of Physics, he was one of the group of great physicists centered at the Cavendish Laboratory. Radioactivity was his special field. His researches on the transformations of radioactive substances earned him the Nobel Prize for Chemistry in 1908,

and many other distinctions. He was knighted in 1914 and made a baron in 1931.

LUIS WALTER ALVAREZ (1911-) is Associate Professor of Physics at the University of California. He carries on researches in nuclear physics.

ROBERT ALDEN CORNOG (1912-) is now Senior Physicist at the Palmer Physical Laboratory, Princeton University. His researches include nuclear physics, radioactive hydrogen and helium 3.

New Germ-Killing Soap Developed

Clean Hands, Fewer Infections Seen As Postwar Result

► CLEANER HANDS and skin, with far fewer germs so that the chances of infection in cuts, scratches and blisters will be much less, is the postwar promise of a new germ-killing soap reported by Dr. Eugene F. Traub, of New York, and Dr. Chester A. Newhall and John R. Fuller, of the University of Vermont, in the medical journal, *Surgery, Gynecology and Obstetrics*.

The soap will have in it a synthetic phenol, dihydroxyhexachloro diphenyl methane, known for short as G-11. Due to wartime restrictions, soap containing this germ-killing chemical cannot be made available at present except for experimental purposes or clinical trial.

In one of the tests reported, soap containing 2 per cent of G-11 was used for all purposes from hand washing to dishwashing for a period of one week.

The persons in the tests then washed their hands and forearms for 75 seconds in a good lather of ordinary toilet soap followed by a 20-second rinse. Samples of the soapy water had only about 250,000 germ colonies compared to about 3,250,000 in the same-sized sample of soapy wash water from persons who had used ordinary toilet soap for a week.

Included in the group using the G-11 soap for one week was a football player. He came straight from practice for the final soap washings. In spite of the dirt on his hands, and contrary to what the scientists expected because of the grimy state of his hands, the soap and water he washed in gave a count of only 290,000 germ colonies, only slightly higher than the average.

A person who uses G-11 soap regularly, the scientists state, has fewer "resident" germs on his skin after two

minutes of washing than a person who washes for 20 minutes with ordinary toilet soap. Previous studies by other scientists have shown that some of the germs on the skin are transients that can be easily washed off with soap and water but that others are in the nature of permanent residents and resist removal.

Daily use of a toilet soap containing G-11, it is suggested, would enable a

surgeon or operating room attendant to keep these resident germs down to an extremely low level. The routine scrubbing before operations might be shortened and irritating germicides might be eliminated without sacrificing any surgical cleanliness. Omission of the alcohol and iodine rinse might be an important economy now, when these chemicals are not readily available.

American Scientist Foretold Conditions for Chemical Manufacture

Chemicals by Calculation

by BERNARD JAFFE

From a new book, *Men of Science in America*, (Simon and Schuster \$3.75).

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➤ GIBBS' PAPER on the equilibrium of heterogeneous substances was full of fresh approaches and brilliant guides to the many problems involved in the manufacture of chemicals. It was a top-flight achievement. "Having greatly extended and developed the method of thermodynamic potentials," wrote Paul S. Epstein, professor of physics at the California Institute of Technology, "Gibbs was the first to realize what a powerful tool it was in the treatment of chemical problems. Once started on this road, he went to the end; we see here a phenomenon almost unparalleled in the history of science. A young investigator, having discovered an entirely new branch of science, gave in a single contribution an exhaustive treatment of it which foreshadowed the development of the-

retical chemistry for a quarter of a century."

For example, in order to clear up the intricate problem of the equilibrium of mixtures such as chemical solutions and metal alloys, early in his paper Gibbs introduced five pages of mathematical equations which are now known as the *phase rule*. The mathematical formulas of the phase rule made it possible to determine in advance the exact concentrations of the various substances that were to be used in making the mixture required. They gave the temperatures and pressures best suited to produce a final mixture whose components would remain in equilibrium with each other, and thus not separate out and destroy the mixture. The phase rule also enabled an experimenter to calculate in advance

the conditions necessary for making physical separations of one or more of the substances found in a complex mixture of salts or metals. Thus the scientist could be spared the expensive and time-consuming business of undertaking thousands of experiments before the final conditions for a successful process could be found. The phase rule was, therefore, an efficient timesaver, and frequently also the only practical key to the solution of hitherto insoluble problems.

According to the phase law, a physical system made up of ice, water, and water vapor is in equilibrium—that is, no more ice will melt to water and no more water vapor will condense to liquid when $F = C + 2 - P$, where:

F (degrees of freedom) =
the number of physical conditions such as temperature, pressure, and concentration, which must be fixed before there can be equilibrium of the mixture.

P (phases) =
the number of parts of any system of substances which can be separated mechanically, such as ice, water, and water vapor.

C (components) =
the number of integral parts of which a system is composed. In the case of the ice, water, and water-vapor system, $C = 1$, since water is the only component.

In such a system of ice, water, and water vapor,

$$F = C + 2 - P$$

$$F = 1 + 2 - 3$$

$$F = 0$$

Hence no physical condition such as temperature, pressure, or concentration can be varied in such a system without destroying a phase, since it has no degree of freedom. The system, can, therefore, be in equilibrium only at one fixed temperature, and with a fixed value for its water-vapor pressure. None of these variables can be arbitrarily changed without causing the disappearance of one of the phases.

John D. Van der Waals, an eminent Dutch physicist who was working at the University of Amsterdam on the equilibrium of gases, read Gibbs' paper, saw its value at once, and incorporated it into his own work. Furthermore, he was so impressed with the importance of the contribution of the American professor that he brought it to the attention of his graduate students. One of these was Bakhuis Roozeboom, a Dutch chemist who was investigating the very complicated and practical problem of the nature of steel, an alloy of iron and carbon. Roozeboom seized the key prepared by Gibbs and used it with success in the clearer understanding of the composition of steel alloys.

Answers to Chem Quiz on Page 25

1. $\text{HIO}_4 \cdot 2\text{H}_2\text{O}$, Periodic Acid.
2. H_2TiO_3 , Titanic Acid.
3. $\text{C}_3\text{H}_5\text{C}_6\text{H}_3(\text{OH})\text{OCH}_3$, Eugenol Acid.

4. $\text{CH}_2\text{CHCH}(\text{CH}_3)\text{COOH}$, Angelic Acid.
5. $\text{Ca}(\text{CaF})(\text{PO}_4)_3$, Apatite.

One of the Chemical Wonders of
Our Age is Chemical from Mold

Progress Reports On Penicillin

► A NEW METHOD of giving penicillin treatments which may be more effective in lung diseases such as pneumonia and bronchiectasis is being tried on patients at Huntington Memorial Hospital, Cold Spring Harbor, N. Y. The method consists in having the patient inhale a mist of very fine particles of penicillin.

Tuberculosis might be treated by the same method, using a mist of promin or some other drug effective against tubercle bacilli instead of penicillin.

The method was developed by Dr. Vernon Bryson, at the Long Island Biological Laboratory here. Treatment of the patients is under the direction of Dr. Edwin Grace, of Brooklyn.

First patient treated was a discharged Marine who had a lung infection. Poison from this "putrid, foul lung" had apparently reached his brain, causing symptoms of mental disease which kept him in a mental hospital for nine months. At this time the penicillin inhalation treatment was given. It did not by itself cure him, probably because the infection had gone on too long. But it did clear up the infection to the point where an operation could safely be performed. The operation consisted in removal of the lung. Since then the man has been getting well. His mental condition cleared up and he has left the hospital.

Penicillin inhalations given to a woman with bronchiectasis within 10

days reduced the amount of sputum she coughed up each day from an ounce and a half or two ounces to a teaspoonful. This striking improvement did not last, the amount of sputum increasing to about half its former level. However, she is "50 per cent better than she was," Dr. Grace said.

The value of the mist inhalation method of giving penicillin or other drugs for lung diseases lies in the fact that it gets the drug directly to the site of the infection, Dr. Bryson explained in a report at a Huntington Hospital Staff Meeting. Studies with mice and rabbits have shown this.

The treatment is particularly suited to chronic lung infections in which areas of fibrous tissue have developed. These areas have relatively little blood supply and are more or less walled off from the rest of the lung. Consequently penicillin or other drugs injected into the muscles or blood stream may not reach the site of infection in sufficient quantity to do any good.

The inhalation treatment is given with a nebulizer, which is a special kind of atomizer with a glass baffle. Compressed air or oxygen is used to force the penicillin solution against the glass baffle hard enough to break it up into very small particles. The particles are so small it would take 25,000 of them laid side by side to make one inch. Unless the particles are this small they will not get down deep into the lungs where the infec-

tion is. The size of the particles may be varied according to the size of the structure in the lungs where the infection is.

When taking the treatment, the patient is instructed to take a deep breath of the mist from the nebulizer and then to hold the breath as long as possible. Then another deep breath, and so on. Masks are not efficient for the treatment, since too much penicillin is wasted.

Possible Cancer Weapon

► A CLUE to what may and scientists hope will become a weapon against cancer has been turned up in studies of penicillin. The latest of these studies are reported by Dr. Margaret Reed Lewis, of the Wistar Institute of Anatomy and Biology, Philadelphia.

Penicillin itself, effective remedy for many germ-caused diseases, is not the anti-cancer weapon, but certain impurities that accidentally got into one lot of penicillin may be. Last March Dr. Ivor Cornman, now Corporal Cornman, found that a preparation of penicillin killed mouse and rat bone cancer cells growing in culture tubes outside the body. Non-cancerous cells were unharmed.

Subsequent tests by Mrs. Lewis, with whom Cpl. Cornman worked before induction into the Army, and by Dr. George O. Gey, of the Johns Hopkins Hospital and Medical School, showed that penicillin is not the anti-cancer weapon. Highly purified preparations of penicillin, including those now being prepared for treatment of patients with germ diseases, have no damaging effect on either cancerous or non-cancerous cells, these scientists found.

Tumor cells, however, were killed and normal cells unharmed, Mrs. Lewis now reports, when treated with certain dosages of a yellow sodium salt of penicillin. Apparently this preparation contains some substance that is lost in the highly purified penicillin preparations. Mrs. Lewis suspects that this substance, which may be the one that damaged the rat cancer cells, is either lecithin or lithium. She is starting tests now to check this point.

Lecithin is a compound found in egg yolk and nerve tissue as well as other animal tissues. Lithium is a white metal, the lightest of all metals. In the form of various salts, lithium has had some medical use.

Penicillin for Anthrax

► ANTHRAX, for which no completely satisfactory treatment has yet been developed, may yield to penicillin, it appears from a report by Dr. F. R. Heilman and Dr. W. E. Herrell of the Mayo Clinic, Rochester, Minn.

In trials with mice, they found that slightly more than half the animals treated with penicillin could be protected against 10,000 times the lethal dose of anthrax germs even when treatment was not started until 16 hours after the mice had been inoculated with the germs. In other trials, starting treatment within an hour and inoculating fewer germs, all the treated mice survived and all the untreated ones died.

Anthrax, which humans get from hair, hides, bristles and wool of infected animals, has apparently decreased in incidence and fatality in recent years. It is still, however, an important disease problem in certain regions. Antiserum, arsenicals and

sulfa drugs have proved of some value in its treatment but their use still leaves something to be desired, the Mayo doctors state.

Penicillin for Syphilis

➤ **EARLY SYPHILIS** in expectant mothers is either cured or at least suppressed, miscarriage and stillbirth are averted and apparently healthy babies are born when the mothers are treated with penicillin, Dr. J. W. Lentz, Dr. Norman R. Ingraham, Jr., Dr. Herman Beerman and Dr. John H. Stokes, of Philadelphia, have reported in the *Journal of the American Medical Association*.

Babies born with syphilis make a good response to penicillin treatment. Not enough time has elapsed to be sure whether mothers or babies are really cured of the infection and more study is needed to determine the best dosage of the mold chemical. The Philadelphia doctors, however, appear hopeful that penicillin may prove as good as or better than present treatment with arsenicals.

Penicillin for Meningitis

➤ **PENICILLIN** combined with sulfa drugs saved 12 out of 13 patients suffering with meningitis due to pneumonia germs, a once 100 per cent fatal disease, Dr. Antonio J. Waring, Jr., and Dr. Margaret H. D. Smith, of Baltimore, have reported in the *Journal of the American Medical Association*. The penicillin-sulfa drug combination, they find, is more effective than either penicillin or sulfa drug alone or sulfa drug combined with serum.

Penicillin for Boils

➤ **MULTIPLE BOILS** following prickly heat or heat rash in babies, a common

and often refractory problem in the south during warm weather, clear up more rapidly with penicillin than with any other known treatment, Dr. Rose Coleman and Dr. Wallace Sako, of New Orleans, report.

Penicillin Sensitivity

➤ **THE CASE** of acquired sensitivity to penicillin, analogous to drug or serum allergy, is reported by Dr. Leo H. Crip, of Pittsburgh. It took the form of hives which showed as soon as a penicillin injection was given. The reaction continued until penicillin treatment was stopped.

Cellophane Increases Yield

➤ **FASTER PRODUCTION** and increased yields of penicillin are obtained when bags or strips of Cellophane are placed in the culture medium in which the penicillin-producing mold grows, Dr. Gregory Schwartzman, of Mt. Sinai Hospital, New York, has reported.

In one test, the mold growing with the Cellophane bag or open bowl started producing penicillin three days earlier than mold without the Cellophane. On the day when penicillin first appeared in the cultures without Cellophane, the concentration of the drug in the Cellophane cultures was already 30 times greater.

Observation that young colonies of the mold tended to develop nearer the side walls of the flask they grew in than toward the center of the surface of the fluid suggested that introduction of some supporting material would help them grow faster.

Even under conditions unfavorable for the production of penicillin, the Cellophane speeds production and yield.

Radium Speeds Production

► **PENICILLIN** production schedules can be speeded by two or three days through the use of radium or other radioactive substances, it appears from a report by Dr. Richard Jahiel, Miss Ethel Guberman and Rafael Kazdan, of the Biochemical Research Laboratories of the Canadian Radium and Uranium Corporation.

Basis for the experiments of the Canadian scientists is the fact that minute amounts of radium emanation, or other radioactive substances, have an exciting action on the growth of living substances although radia-

tion from larger doses has a destroying power.

When porcelain tubes containing radium were added to the bottles in which the mold, penicillium, was growing, the peak of penicillin secretion came at least two or three days before it was reached in bottles of mold growing without irradiation.

Adding a fluorescent substance, such as the dye, fluorescein, to the growth medium in which radioactive substances are present improves noticeably the effects of the radioactive elements.

A Third Science Talent Search Essay By a 17-year-old Girl

Experiment in Chemical Gardening

by PATRICIA ANN DUNKEL, 17

Brighton High School, Rochester, N. Y.

► **MY PURPOSE** in attempting this experiment was to discover for myself more about plants and how they grow. Some people label ease in growing plants "green thumbs," but I think it consists mainly of understanding a plant as an organism with certain needs. If it is supplied these essentials, it will grow. I've watched plants thrive in my garden and have enjoyed taking care of them. But delving into the intricacies of hydroponics was an adventure, although I soon discovered it was based on the same fundamental principles as gardening in soil.

Hydroponics, or the growing of plants without soil, has been a much-publicized subject in recent years. If it could be perfected for use on a more

superior commercial basis than agriculture, it could solve many of the problems of world peace. Small nations with huge populations would be able to grow enough food intensively by chemical farming to feed their starving millions.

My first materials were very simple. Two plates, two or three neutral blotters, a package of seeds, and a nutrient solution were all that were necessary for the first seedlings. The nutrient solution was composed of simple household chemicals:

- $\frac{1}{4}$ teaspoon Epsom salts
 - $\frac{1}{4}$ teaspoon saltpeter
 - $\frac{1}{4}$ teaspoon household ammonia
 - $\frac{1}{2}$ teaspoon baking powder
- in one gallon of water

This supplied the basic elements, magnesium, sulfur, potassium, nitrate, more nitrate, sodium, and carbon, as well as the various nutrients contained in the tap water. Having placed some broccoli seeds between two blotters and poured on the nutrient solution, I was surprised to find that it only took two days for the seeds to begin sprouting. A seed cover burst open and a small, white curly tip emerged. As this white tip developed, the root hairs became visible. Exposed to light, the sprout grew upward and became green. Two heart-shaped leaves developed opposite each other on the stalk. In five days my plants were, on the average, $1\frac{1}{2}$ inches tall. And this was still only a solution of the simplest kind, with nothing except a blotter to support the roots of the seedlings.

Although this method of germination applies only to small seeds, I attempted to sprout watermelon seeds in this same manner. I have watched them for four weeks, and they have not yet sprouted. A few have produced minute white tips, but these tips do not seem able to develop further. On the other hand, when tomato seeds were flooded with the nutrient solution, instead of being kept between moist blotters according to the approved technique, germination was definitely retarded, but the seeds did finally sprout, within a few weeks, when the excess moisture was removed.

How did one of these small plants grow? Stored in the seed itself are starch and food enough to allow the plant to germinate and grow for some time. As it grows, small openings on the underside of each leaf called stomata absorb from the air carbon di-

oxide which dissolves in the sap of the leaves and is transported to the cells in which the chlorophyll is located. Water is absorbed by the root hairs and reaches the chlorophyll cells by osmosis. Here water + carbon dioxide + chlorophyll + the magical chemical action of the sun's rays produce a simple sugar. From this simple sugar, more complex sugars and other products essential to the plant are formed.

When the plants were about $1\frac{1}{2}$ inches tall, I transplanted them into a larger container, using glass wool to support their roots, and making up a more complete nutrient solution. This complete solution contained:

4.2 cc stock solution of KNO_3
 8.4 cc stock solution of $\text{Ca}(\text{H}_2\text{PO}_4)_2$
 4.2 cc stock solution of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
 dissolved in one liter of water.

To this was added a solution of trace elements, which supplied the plants with manganese, boron, copper, and zinc.

Trace element solution:

Manganese sulfate	1 gram
Boric acid	1.5 grams
Copper sulfate	.5 gram
Zinc sulfate	.5 gram

in one quart of water.

(one tablespoon of this solution in one gallon of nutrient solution). Because iron is toxic in large quantities, yet essential to plant growth, ferrous sulfate should be added in prescribed quantities each time the solution is changed.

I allowed the plants to grow in this solution for about two weeks. At the end of the first week I refilled the container with fresh solution. Of course, more solution was poured on the plants when they needed it. The third leaf,

a dark curly green with scalloped edges, characteristic of the broccoli plant, began to grow between the two heart-shaped leaves. On testing the solution for relative acidity at the end of the two weeks, I found that the pH was approximately 6. For proper growth the pH should be between 5 and 6.

To find out by proof which elements were essential to a plant, I began to try to work out a deficiency study. Leaving two of the plants in the complete solution, I transplanted two others into a special solution lacking calcium. This solution was composed of:

9 cc of stock solution for each of the four chemicals:

Potassium nitrate
Sodium phosphate
Potassium chloride
Magnesium sulfate
in one liter of distilled water.

Lack of calcium primarily hinders root development. Small roots disintegrate and small leaves at first turn dark green and then wither and die. It is important for neutralizing acids within the plant. But my plants have not yet been in the solution long enough for the symptoms to show definitely.

My most marked result was due to approximately a gram of sodium chloride in a test tube of complete solution. In two days the plants wilted and died, probably due to the unbalanced osmotic pressure, or perhaps the resulting salt concentration within the plant.

I also made a solution using potassium permanganate, an oxidizing agent, to show its effect on the plants. Under the microscope, a few days

later, the thin lines of the roots could be seen, but the cells near the edges were obviously being eaten away. To the naked eye the roots had been stained purple and the leaves were beginning to wilt.

Using solutions prepared similarly to that showing calcium deficiency, I placed two plants in each test tube to be studied respectively for deficiencies of nitrogen, potassium, and phosphorus, but these have not yet shown conclusive changes.

Nitrogen is one of the most essential plant elements, because it combines with simple sugar to make simple amino acids, the plant protein. Thus, a lack of nitrogen produces a correspondingly smaller plant. Phosphorus is similarly made into proteins. Potassium aids photosynthesis and can be detected by the premature breakdown of the younger foliage. Thus, in a few more days, I hope my deficiency studies will show these results.

And so, though my results are not yet complete, my experiment has been worthwhile to me, since I've taught myself more about plant growth. In a chemical solution, one has the advantages of watching the actual plant growth from seed and the development of the roots, whereas in the ground this is impossible. There is another lesson to be learned from chemical gardening. In dirt-gardening one is not as conscious of the elements present as one probably should be. Thus, in chemical gardening, because of the control of the elements, better plants can be grown by regulating the needs of the plant.

I am very interested in bio-chemistry and hope to continue in this general field in my further work in science.

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Second in a Series on Presenting an
Introduction to Chemistry

States of Matter

by HELEN M. DAVIS

SECOND in a series of articles
appearing monthly that take the
reader along the pathways of
basic chemistry, by easy stages.

► A FEELING of loneliness comes from
looking at the twinkling points of light
in the heavens on a starry night and
reflecting that we may occupy the only
inhabited satellite of all that myriad of
suns. A similar feeling of awe comes
to the scientist who sees every object
of this earth as a swarm of spinning,
darting molecules constantly in motion.
They are always bumping into
each other and starting off anew on
journeys infinitely short to us, as we
watch them, but infinitely long compared
to their own diameters. The proportion
of matter to empty space in the
submicroscopic world seems about
what it is in the stellar universe. And
beyond that, again, lie the tinier universes
within the atom.

Particles of matter most widely
dispersed from each other make up a gas.
They are as free as air. No matter what

the kind of gas, the molecules composing
it keep their distances from one another,
so that, under the same conditions,
equal volumes of true gases always have
the same number of molecules.

That is a remarkable statement, considering
the fact that no one has ever seen the
molecule of a gas. When Avogadro,
Italian physicist, made the pronouncement
in 1811, the scientific world was loath to
accept it as anything surer than a "hypothesis."
But so many calculations based on it have
worked out to results verifiable by exact
weights and measures that "Avogadro's
Law" is now accepted.

In dealing with gases, it is always
necessary to specify the conditions under
which the measurements were made.
Heat makes gases expand. Pressure makes
them contract. It might be quite hopeless
to compare different measurements of
gases if these changes did not take place in
a very simple and regular way.

The Gas Laws

That the volume of a given mass of
gas varies inversely as the pressure, if the
temperature remains constant, was
discovered by Robert Boyle about 1660,
while he and Robert Hooke were studying
the "spring in the air." More than a
century later Charles and Gay-Lussac
independently discovered the law of
variation with temperature, that, at
constant pressure, the volume

of a given mass of gas increases $1/273$
of its volume at 0°C . for every degree
rise of temperature, and contracts at
the same rate. Standard conditions
adopted by scientists for gas measurement
are 0°C . and the standard atmosphere,
760 mm. of mercury. When thermometer
and barometer readings are taken, it is
easy to convert the actual conditions
under which a gas

is measured to the corresponding standard conditions and determine the true volume, by a simple exercise in arithmetic.

When a chemist wishes to compare equivalent masses of different substances, he weighs out a number of grams equal to the molecular weight of the substance. This mass he calls the gram-molecule. When the substance weighed is a true gas, one gram-molecule of it at 0° C. and 760 mm. pressure occupies 22.4 liters. This is one of the methods by which molecular weight, and hence atomic weight, is determined.

The fraction $1/273$ of the volume of a gas is an intriguing figure. No true scientist could resist trying to find out what would happen if a gas were made to contract $273/273$ of its volume, by cooling it down far enough. Theoretically, all molecular motion would cease. It is a moot question whether, with its pressure gone, a gas could continue to exist.

In any case, the rate of gas expansion and contraction gives us a scale for measuring temperatures which gets

The Boiling Point

The phenomena familiar to us in boiling water are repeated for most substances, whatever the temperature at which they boil. Bubbles form in the liquid. Vapors which may make themselves known to any of the five senses begin to rise from the surface. The surface itself becomes vague and cloudy. The liquid is turning into a gas. It may not be "boiling hot." Metals boil at the surface of the sun at temperatures which would vaporize us instantly, while liquid air boils at temperatures where we would perish

away from arbitrary standards, and so is known as the Absolute scale of temperature. Practically, its degrees are the same as those of the Centigrade scale, but its zero point is -273° C. In making computations by the gas laws, the Absolute scale is used.

Those who do not believe that finite mortals can ever attain the Absolute of anything prefer to call it the Kelvin scale, after William Thomson, Lord Kelvin, who did so much low temperature investigation. It is well to remember that at the temperature of liquid air and below, the Kelvin scale approaches zero as a limit. Lowering the temperature of a gas from 2° to 1° K. is a vastly greater undertaking than lowering it from 275° to 274° K.

The gas laws apply to substances far removed in temperature and pressure from their boiling points. Superheated steam, for example, is a dry gas which obeys the gas laws perfectly. But steam issuing from the spout of the teakettle is wet with water vapor, and does not conform to the gas laws so completely.

from the cold. Chemicals change state through an infinite range of temperatures. A few, for variety's sake, even boil at temperatures lower than their melting points, so that they "sublime" directly from the solid state to that of a gas.

Watching the agitated surface of a liquid through which bubbles rise and break, with a puff of liquid-carrying vapor and a fall of droplets, it is easy to imagine the individual molecules wrenching themselves away from entangling alliances and finally flying

away in the freedom of a perfect gas.

Liquid particles are much more tightly bound together than those of a gas. Instead of soaring away into the air, they slip and slide over each other to fill whatever container they are poured into. Liquids may be limpid as the purling brook or viscous as cold molasses. Like water, they may wet the sides of the container and form a concave meniscus or upper surface. Or, like mercury, the meniscus may curve downward from center to edge, and the liquid may draw itself together and shrink away from other substances.

This behavior is due to differences in surface tension. The surface is the boundary between gaseous and liquid matter. It offers real resistance to escape of molecules from the liquid, although a few do escape constantly by evaporation.

Much study of surface tension has recently been made in connection with

the thin films of plastic materials used for many purposes. Weird and beautiful forms result from materializing the mathematician's curves in wire or thread and stretching films of molecular thickness across them. Fascinating scientific hobbies have grown up around this field of super-soap-bubbles.

In the liquid, particles are constantly in motion, always drawn toward each other by forces of molecular attraction, always tending to fly apart in their incessant darting about which increases as the liquid is heated. In the other direction, molecules slow down as the temperature is lowered, until another point is reached at which the substance once more changes state, and becomes a solid. This change is as abrupt and dramatic in a "pure" chemical as is the boiling point, and melting and boiling points are characteristic properties by which chemicals are recognized.

The Solid State

In the solid state the smallest particles are packed still more closely together than in the liquid. In materials the chemist uses, these smallest particles usually arrange themselves into definite geometric shapes, forming characteristic crystals of each element or compound.

Crystals are built on infinite variations of four simple patterns. The most complicated of these patterns is familiar in the lacy structure of the snowflake. Its gossamer spokes are the ribs upon which heagonal prisms and pyramids might be built up, and some minerals are found with those shapes.

The other three classes of crystals employ our familiar three dimensions. They have axes of symmetry in two

directions, like the North-South and East-West partnerships of the Bridge table. The third dimension, naturally, is Up-Down. In the first class of crystals these directions are all at right angles to each other, and the crystallographers have learnedly christened it the Orthorhombic, which means just that. There are subclassifications, according to the relative lengths of the axes.

The second class of crystals leans in one direction, and so is called the Monoclinic. If a model is needed to make the difference clear, think of a pack of cards. When in the box they are like an orthorhombic crystal. Take the pack out and give the edge a push, which an engineer would call a "shear-

ing stress," in any direction. A line joining the center of the top card to the center of the bottom card would now be inclined to the planes of the cards, which are all parallel to one another.

Finally, in the Triclinic system of crystals, all three angles are inclined to each other. For this model, the playing cards themselves are no longer square, but have been distorted into rhomboids, and the pack "sheared."

These are the basic patterns of crystal forms. In nature every possible change is rung on these patterns by branching, twinning and modification of every sort, to give the beautiful diversity so familiar among snowflakes. That the crystal structure extends clear down to the level of the atom is proved by the photographs in which X-rays are refracted by using crystal lattices as gratings.

Solid Phases

Crystallization is not only characteristic of individual substances. The same substance may, and often does, crystallize in different ways under different conditions. One form is stable at certain temperatures and pressures. If these conditions change, the whole solid and seemingly inert mass may suddenly execute an about-face and change atomic partners. Some of our earthquake waves originating deep in earth's crust may be the result of such an Atomic Reel.

An American scientist, Willard Gibbs, professor of mathematical physics at Yale University, in 1876-78, by a prodigious exercise of mathematical calculation, worked out the laws by which equilibrium between these

We know that atoms are not motionless, even in solid crystals. In simple elements we may imagine the atoms, for example of gold, although in constant vibrating motion remaining, on an average, within the framework of an octahedron. If one strays, it is immediately replaced by another exactly like it.

In a compound like sodium chloride, atoms of sodium and of chlorine may perhaps alternate to build up the cube structure. In Na_2SO_4 a balance of forces between the seven atoms of the three elements must be maintained. Some salts require a definite number of molecules of "water of crystallization" to build up their large, glassy crystals, notably the "vitriols" and the alums. Growing spectacular crystals is one of the standard indoor sports of chemistry.

chemical states occurs. His formula is known as the Phase Rule. He defined as phases the different forms in which a substance occurs, which can be separated mechanically. Thus, there can be but one gaseous phase, since all true gases diffuse freely into one another. Liquids which do not mix make two phases. Some liquids under some conditions will maintain two phases and also an emulsion of one in the other, and if the emulsion is stable within fairly wide limits it too will be a phase. Solids will make one or more phases, one of the chief differences being different crystalline forms.

Substances will exist in their different phases according to conditions of temperature and pressure. Water is a

simple substance which, under atmospheric pressure and within the limits of temperature in which we live, exists in the liquid phase. If we hold the pressure constant (in other words, let it alone) we find that water changes to a solid at 0° C. or to a gas at 100°. But if we hold the temperature constant and vary the pressure, we find that the temperatures at which these changes take place are different. This is apparent even in practical affairs on high mountains and in airplanes, where the difference in atmospheric

pressure lowers the boiling point of water enough to upset the usual schedule for cooking eggs.

Water is a system of one component. If we add a pinch of salt we introduce another dimension into the problem of measuring its behavior, for salt affects the freezing and boiling points of water. The concentration of the solution—the relative weights of salt and water—must be known, and the shift of freezing and boiling points with varying conditions for varying concentrations must be mapped out.

The Phase Rule

Gibbs called these varying conditions of temperature, pressure and concentration degrees of freedom. His formula is

$$F = C + 2 - P$$

when F is the number of degrees of freedom, C is the number of components of the system and P is the number of phases possible.

With the Phase Rule as a guide, it is possible to map out strange territories which can never be inhabited by man, where, under pressures we cannot bear and temperatures impossible for life, mercury is a solid, or iron is a gas, or ice is blue. Again we glimpse man as a transient stranger living under special conditions in a vast inhuman universe.

When exploring the boundaries of these chemical fields we find conditions most fascinating along the edges and corners where phases meet, the so-called "critical" temperatures and pressures.

For a one-component system, like

water, the Phase Rule works out as

$$F = 1 + 2 - P$$

and if we allow one phase we find there are two degrees of freedom,

$$F = 1 + 2 - 1 = 2$$

This means practically that both temperature and pressure can vary widely without a change of phase. But if we want to explore the boundary where two phases can exist at the same time, only one degree of freedom is possible,

$$F = 1 + 2 - 2 = 1$$

If a certain temperature is selected, that degree of freedom is used up, and the necessary pressure is fixed. If the pressure is chosen, the requisite temperature must be met. These points are determined experimentally. They can be plotted on a chart, laying off temperature in one direction and pressure in another, and the area can be mapped in which the liquid phase, for example, can exist.

Most remarkable of all, when

$$F = 1 + 2 - 3 = 0$$

we see that there is just one point in the universe at which water can exist as ice, water and steam all at one time. This "triple point" occurs at the pressure of 0.00602 atmospheres, or 4.6 mm of mercury, and the temperature of 0.0075° C.

A little water in a crucible which is set in a dish of ether under a bell-jar will be cooled by evaporation of the ether as the air is pumped out. At the same time the pressure drops, and the watcher is soon rewarded by seeing

an ice-film forming around the edge of the water while boiling goes on briskly through a hole in the center of the ice. Although there are no degrees of freedom, the phenomenon is not static, but presents a picture of intense activity of balanced forces.

In chemical manufacture it is essential to know the boundaries of conditions for the material wanted so as to work safely within them. Otherwise the operator goes about his work with the blindness of the alchemists.

Colloids

The classical chemist tries to make a definite crystalline compound, with a sharp melting point to distinguish it from all the other white powders in the universe. But not every substance in the world is so definite. Waxes, greases, smokes and goo refuse to behave like chemist's pets. At first the chemist ignored them. Then he named them "colloids" and began to classify them.

Here, between gross mixtures and chemical combinations, he found suspensions and emulsions uniting matter in various states. Solid particles of gold of colloidal dimensions float in water to form "Purple of Cassius." Or the gold remains suspended in that strange "super-cooled" liquid we call glass to give the glowing red of medieval cathedral windows. These are dispersions of solids in liquids. Lubricating greases combine the solid property of staying put with liquid mobility in the colloid state. These, too, are dispersions of solids in liquids.

Solid bits of carbon float in air to give industrial cities their murky atmospheres. Solid bits of flesh-searing

chemicals float in air to form one kind of poison gas. These are dispersions of solids in gases.

Cooks taught colloid chemists many tricks, for such culinary stand-bys as milk and eggs, gluten and starch are typical colloids. Whipped cream and meringue are examples of foam, the dispersion of gas in liquid.

Mayonnaise is a typical liquid in liquid dispersion. So long as the egg phase is the dispersing medium, oil can be beaten into it, and the mayonnaise merely gets thicker. But as the amount of oil increases, the emulsion becomes more and more unstable. If too much oil is put in, the emulsion suddenly reverses itself and becomes a dispersion of egg in oil—to the disgust of the cook, whose skill should consist of knowing just where to stop. The vinegar which is sometimes added to mayonnaise to make the taste sharper increases the hazard of separating the mixture—an example of a general rule in handling colloids: the presence of an electrolyte (i.e. an ionized solution) tends to break down an emulsion.

Ionization

In the range of still smaller particles, we approach the condition of true solution. In common speech we sometimes confuse the terms "melt" and "dissolve." In chemistry, the two must be carefully distinguished. Substances melt when they change from the solid to the liquid state on heating. Substances dissolve when they disappear into a liquid to form a solution by molecular dispersion.

The alchemists, who were interested chiefly in metals, worked in furnaces with melted gold, brass, lead and the like. The modern chemist works in a cooler laboratory with solutions of the metals, and has to know a great deal more about them.

In general, acids attack metals, corroding the surface, gradually causing the metal to disappear. The resulting solution may continue to look like water, or it may acquire a color from the metal. Copper salts are sapphire blue, nickel salts are green, those of cobalt are blue and pink, chromium gets its name from the beautiful variety of colors its salts display.

While the metal is disappearing in the acid, little bubbles of gas are seen to rise through the liquid and break at the surface. These are bubbles of hydrogen, which may be collected and exploded with oxygen to form water, or imprisoned in a balloon bag to lift an airship.

The metal in dissolving in the acid took the place of the hydrogen, and set it free as a gas. When the hydrogen was in the acid it was not a gas. Yet we have learned by careful and clever experiments that it was free to move about alone in the liquid. It was dis-

sociated from the chlorine which made up the rest of its molecule, if the acid is HCl, or from the sulfate or nitrate radical, if it is sulfuric or nitric acid that we are using. These ultimate particles of matter in solution we call ions. They are atoms or groups of atoms, dissociated as parts of molecules and carrying electric charges because of that dissociation.

Pass an electric current through a solution, and the ions gain or lose electrons according to their needs, and appear at the electrodes in their elemental forms. Add a metal to an acid solution, and hydrogen robs the metal of electrons to assume its own gaseous form. The metal atoms wander as ions through the solution until they can find electrons to complete their electron complement.

This can happen in several ways. The water molecules may evaporate, rapidly if subjected to heat, slowly if just left alone. As the water evaporates, the number of ions the solution can hold is reached, and the ions begin to combine. The salt begins to crystallize out. Zn^{++} ions unite with two Cl^- ions each, and white crystals appear around the sides of the beaker just above the surface of the liquid.

In another case, Ba^{++} ions meet SO_4^{--} ions and form a salt which is not soluble in water. Down comes a white precipitate like a miniature snowstorm in one of those dramatic reactions which chemists like to use as test procedures.

Sometimes the emerging element or compound goes through a second reaction, as when carbonates break down into H_2O and CO_2 .

Replacement

Metals vary greatly in their tendencies to enter into solution, from the very active sodium and its analogues in Group I, which react with plain water, to the "noble" metal, gold, of the other branch of the Group I family. No single acid will dissolve gold. The powerful mixture of nitric and hydrochloric acids was named "aqua regia" by the alchemists because it alone could accomplish the "death of the King."

Heavy metals of other groups also resist acids. For instance, Tantalum was named by its discoverer, Ekeberg, in 1802, because it could stand up to its neck in acid, like its thirsty namesake in Greek mythology, yet be unable to take any of the liquid to itself.

In general, the harder it is to get a metal into combination, the easier it is to get it out. Ores and compounds may be reduced to metal by heating them with substances which take away the other elements in the combination. Metals may be ranked by their ability to displace one another in compounds. The list is found in handbooks as the Electromotive Series.

Isaac Newton in 1669 wrote a letter to a friend, Francis Aston, who was about to take a trip on the Continent,

asking him among other things to investigate a strange spring he had heard of. It was said that if a piece of iron were put into the water there the iron would turn to copper. The story sounded like a record of transmutation and Newton, always the experimentalist, wanted to discover the facts.

Historically, the story is incomplete. We do not have the friend's report. But we know now that the seeming magic was sober fact. Mining men in our own West dump old tin cans (which are mostly iron) into the waste waters from copper mines and get pure copper in exchange, by utilizing the principle of electrochemical replacement.

Iron is more active, more greedily for electrons than copper is. It takes them, and goes into solution. Copper loses them, and comes out. The solution gradually loses the deep blue color due to copper ions and becomes clear or, if the concentration of ferrous ions is high, it assumes a pale greenish tint.

Copper without an electric charge is a red metal. Copper with an electric charge is a blue color in a solution. It doesn't sound reasonable, but it is a fact. We just have to get used to it.

► *THE FLAMETHROWER at work on a Jap pillbox as shown in the Signal Corps photograph on the opposite page is an outstanding example of the use of a chemical weapon in warfare. See also the article on jellied gasoline on page 17.*

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A Bit of Chemical "Magic"

Sodium Silicate Gardens

by JOSEPH H. KRAUS, *Science Clubs of America* Editor

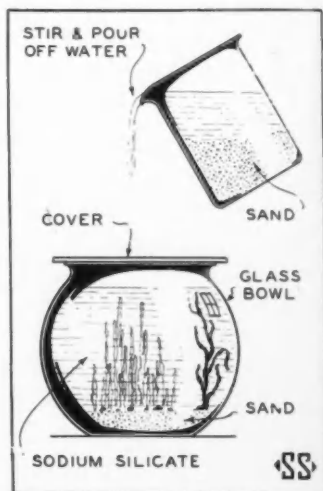
► SMALL FRAGMENTS of various chemicals dropped into a dilute solution of sodium silicate, a popular egg preservative, will produce a colorful mineral garden. Starting to grow almost instantly, it is complete in a few hours. The strange new formations will last for years if handled carefully.

Sodium silicate, popularly known as "water glass," may be purchased from drug or department stores. Either the fresh liquid or one previously employed as an egg preservative can be used for the experiment.

Drop one or two handfuls of sand into a glass vessel or pot. Cover with ordinary water from the faucet, stir and pour off the dirty liquid. Repeat until the water comes off perfectly clean. Now drop enough of the washed sand into the bottom of a small fish aquarium, preferably round, to form a layer about an inch deep. This will be the "soil" of your garden.

In a clean glass mix one part by volume of fresh sodium silicate solution with nine parts of tap water. You can use a wine glass or egg cup for measuring. Stir well to get a perfect mixture of the syrup with the water. Pour enough solution into your prepared aquarium to fill it nearly to the top and set the aquarium aside where it will not be disturbed for several hours.

Should you have on hand some sodium silicate solution which already has been used as an egg preservative,



don't dilute the solution any further. It has probably already been diluted with 10 to 15 parts of water, so just make sure that the liquid is clear.

Allow sufficient time for the liquid to come to rest, then drop a few small pieces of any of the following chemicals into the solution: the sulfates of copper, iron, cobalt, nickel, manganese or aluminum; the nitrates of copper, iron, cobalt, nickel or calcium; the chlorides of copper or iron.

Use Small Pieces

The pieces need be no larger than grains of rice. Use only a few pieces of each of the chemicals you have available. Carefully drop them into the



► **SILICATE GARDEN** as constructed chemically according to the directions in the article. Photography by Fremont Davis.

prepared aquarium so that they cluster together near the center.

Instantly the chemicals will start to grow. Some will be fern-like, others will resemble colorful stalagmites like those seen rising from the floors of natural caverns. But unlike stalagmites, the growth is a result of an osmotic action.

When the mineral is dropped into the liquid, it starts to dissolve and at the same time reacts with the sodium silicate solution to form an insoluble silicate. A sac-like shell forms around the mineral. But the concentration of the solution within the sac now becomes greater than that surrounding the sac, because some of the chemical inside is still dissolving.

When the solutions of different degrees of concentration are separated by a membrane through which they can pass, the solution in which the substances are less concentrated tends

to be exchanged for that in which they are more so. A good example of this action, called osmosis, is water entering through the skin of a dried prune which swells up as a result, while some of the fruit's juices escape through the skin into the surrounding water.

Sac Breaks

The increase in pressure within the sac causes it to distend or rupture at its weakest place, usually at the top. This accounts for the growth which continues until the chemical is exhausted or the growth reaches the surface.

The growth may be stopped at any point by replacing the silicate solution with fresh water. Keep the aquarium filled with water and covered with a glass plate, then the formations will last for years.

You can examine the tube-like construction by breaking off any of the filamentous forms, but handle carefully as they are very delicate.

Sodium Silicate Protects Plumbing

► HOUSEHOLD WATER pipes and plumbing can be protected from corrosion and their life greatly increased by the addition of small amounts of relatively inexpensive sodium silicates to the water passing through them, declared Dr. William Stericker of the Philadelphia Quartz Company at the meeting of the American Chemical Society.

The use of these chemicals in protecting piping has proved successful in pipes made of plain and galvanized steel, brass, aluminum, and some combinations, he stated. Their effectiveness is particularly marked in hot water. The hardness of the water is

not increased, nor is a definite calcium or magnesium content necessary.

Examples were given by Dr. Stericker to illustrate the advantages gained and the methods used for feeding the silicates in laundries, office buildings, apartment houses, residences and factories. Silica as it occurs in soluble silicates is the most effective form, he said. High concentrations help more rapid formation of the protective film. Once this thin tenuous layer is in existence, it can be maintained with more dilute solutions.

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